
SIGILLVM · VNIVERSITATIS · CALIFORNIENSIS
FIAT LVX
MDCCCLXVIII
EX LIBRIS

Missouri Bureau of Geology and Mines
ERNEST ROBERTSON BUCKLEY, Ph. D
Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

TO THE

42nd GENERAL ASSEMBLY

JEFFERSON CITY, MO.:
TRIBUNE PRINTING COMPANY, STATE PRINTERS AND BINDERS
1903.

HEADQUARTERS MISSOURI BUREAU OF GEOLOGY AND MINES, ROLLA, MO.

Missouri Bureau of Geology and Mines
ERNEST ROBERTSON BUCKLEY, Ph. D.
Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

TO THE

42nd GENERAL ASSEMBLY

JEFFERSON CITY, MO :
TRIBUNE PRINTING COMPANY, STATE PRINTERS AND BINDERS
1903

The last no. (1913-14) is

2,000 Copies ordered printed by Senate.

C. ROACH, Secretary.

3,000 Copies ordered printed by House.

JOE TALL, Chief Clerk.

See next vol.

TABLE OF CONTENTS.

ILLUSTRATIONS.

BOARD OF MANAGERS.

His Excellency, Alexander M. Dockery, Governor of Missouri,
ex officio President of the Board....................Jefferson City
Professor Edward M. Shepard, Sc. D., Vice-President.......Springfield
President E. B. Craighead, A. M., LL. D., Secretary......Warrensburg
Hon. H. H. Gregg..Joplin
Hon. W. S. Allee, M. D.......................................Olean

PREFATORY LETTER.

Bureau of Geology and Mines,
Rolla, Mo., Dec. 1, 1902.

To the President, Governor A. M. Dockery, and the Honorable Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to submit herewith a report on the work of the Bureau of Geology and Mines from September 12th, 1901, to the present date. An idea of the diversified character of the work of this department cannot be adequately conveyed in a report of this nature, but it is hoped that enough has been said to emphasize the importance of this department to the people of the State.

I wish in this place to express to the members of the Board my appreciation of the deep interest which they have manifested in the work of the Bureau. Both individually and collectively the members have contributed largely to whatever success may have been attained by the present administration. No sacrifice of time or attention has been too great to further the interests of this department.

Your obedient sir,

E. R. BUCKLEY.

INTRODUCTION.

At the last session of the Legislature, sections 7502 and 7502a of the law creating the Bureau of Geology and Mines were amended so as to read as follows:

"Section 7502. The board of managers are authorized, as soon as they are organized, to appoint one state geologist, who shall be a person of competent scientific and practical knowledge of the sciences of geology and mineralogy, and whose headquarters shall be located at the state school of mines at Rolla, who shall be the director of the survey, and said state geologist may appoint such assistants and subordinate assistants and laborers as may be deemed necessary in order to make a thorough scientific, geological, and mineralogical survey of the state.

Section 7502a. The board of managers of the bureau of geology and mines are hereby authorized and directed to transfer all instruments, books, charts, cabinet collections and other property of the state of Missouri now under the control of said board to the state school of mines at Rolla and establish the headquarters of the geological survey at said state school of mines."

In accordance with the above instructions, the headquarters of the Bureau have been removed from Jefferson City to Rolla and are now locatd in a building belonging to the School of Mines and known as the "Club House." All instruments, books, charts, cabinet collections and other property of the Bureau have also been transferred to Rolla, as directed.

At the time of taking charge of the Bureau, September 12, 1901, the furniture, fixtures, library and cabinet collections were packed as they had been shipped from Jefferson City. It, therefore, became my duty not only to plan the work of the survey, but at the same time to oversee, personally, the unpacking of the furniture, library and cabinet collections; the cleaning, papering and repairing of the building; the erection of the cabinets; and many other details incident upon the removal of the Bureau to Rolla. This work has consumed much of the spare time of

myself and assistants, although a greater part of the work of unpacking and arranging of the mineralogical and paleontological specimens was done during the winter evenings.

The Bureau is now in excellent working condition and, if sustained, it should become an indispensable factor in the development of the resources of the state.

REPORTS FOR DISTRIBUTION.

On the 12th of September, 1901, there were the following volumes of the reports of this Bureau remaining for distribution:

Preliminary Report on Structural and Economic Geology.—Vol. XIII, 1900, by John A. Gallaher	3632
New Year's Announcement, Jan. 1, 1901, by John A. Gallaher	463
Biennial Report of the State Geologist to the 41st General Assembly, by Leo Gallaher	493
Higginsville Sheets (without maps), by Arthur Winslow	275
Areal Geology, Vol. XII, Part II, by C. F. Marbut and G. C. Broadhead	242
Biennial Report of the State Geologist to the 39th General Assembly, by Chas. R. Keyes	210
Coal Deposits, Vol. I, by Arthur Winslow	189
Lower Carboniferous Crinoids, Bul. No. 4, by S. A. Miller	9
Boone County and Ozark Uplift, G. C. Broadhead	8

Distribution.—The above reports have been distributed upon application, provided the request were accompanied with stamps to cover postage. Volume I has been sent out upon receipt of 15 cents in stamps, and Volume XIII upon receipt of 25 cents in stamps. The other reports require from 2 to 22 cents each for postage. Volume I, Bulletin No. 4 and the bulletin on "Boone county and the Ozark Uplift," have been exhausted and are no longer obtainable from this office.

Since September 12, 1901, there have been distributed 45 copies of Volume I and 244 copies of Volume XIII.

SPECIMENS IN THE MUSEUM.

Upon taking charge of the Bureau September 12, 1901, there were about 5,250 specimens in the museum cabinet, including fossils, coal, clay, lead, zinc, iron, stone, barite and other ores. Since that time there have been added to this collection about six hundred new specimens of fossils, ores, rocks and clays, mainly from the Cambro-Ordovician formations in the south central part of the state.

LIBRARY.

The library contained about 3,700 books and pamphlets when turned over to the present administration. Since that time there have been added about 280 books and pamphlets, received in exchange for the publications of the Bureau. The library, as well as the museum, is a very important part of the Bureau, but the funds have not been sufficient to classify and build it up as it should have been.

PERSONNEL OF THE BUREAU.

The following is a list of the persons employed by the Bureau during the period covered by this report with the compensation stated in each case:

E. R. Buckley, Director and State Geologist, $3,000.

H. A. Buehler, Assistant Geologist and Chemist, $660 and $720 since September 1, 1902.

Sydney H. Ball, Assistant Geologist, $720.

A. F. Smith, Assistant Geologist, $720.

C. F. Marbut, Assistant Geologist during summer field season, $100 a month.

F. B. Laney, Field Assistant, $35 a month while in the field, about four months.

Carl Smith, A. T. Sweet and Otto Veatch, Field Assistants, without compensation other than expenses.

T. J. Craig, Draftsman, $45.00 a month; employed about two and one-half months.

Stenographer, $300.

Janitor, $216.

INTERESTS WHICH THE BUREAU OF GEOLOGY AND MINES REPRESENTS.

Many of the states and territories in which mining is an important industry and nearly all of the foreign countries have a department known as "The Bureau of Geology and Mines," or "The Geological Survey." Among the states, besides Missouri, which support such a department, may be mentioned New York, New Jersey, Maryland, Michigan, Pennsylvania, Virginia, Texas, North Carolina, Alabama, Louisiana, Wisconsin, Ohio, Illinois, Iowa, Minnesota, Oklahoma, North Dakota, Kansas, Nebraska, California and Washington.

That the mining industry of Missouri warrants the maintenance of such a department is shown by the statistics of production of lead, zinc, coal and other products. Missouri ranks first in the production of zinc,

which, according to the State Mine Inspector's report for 1901, amounted to 224,073 short tons, valued at $5,308,671. Missouri ranks second in the production of lead, which, according to the above referred report, amounted, in 1901, to 109,376 short tons, valued at $4,865,518. Missouri ranks first in the production of barite. The production for 1901 was 32,388 tons, with an estimated value of $113,348. She ranks sixth in the production of clay wares, amounting, in 1901, to $4,474,553; sixth in the production of limestone, amounting, in 1901, to $1,362,272, and thirteenth in the production of bituminous coal, amounting, in 1901, to 3,802,088 short tons valued at $4,707,164, according to the report of the United States Geological Survey. These industries alone add each year to the wealth of the state between twenty and thirty millions of dollars. What these industries may mean to the state in the future cannot be foretold. Suffice it to say that the vast underground wealth of this state has scarcely been touched.

THE FUNCTIONS OF A GEOLOGICAL SURVEY OR A BUREAU OF GEOLOGY AND MINES.

The work which a Bureau of Geology and Mines is called upon to perform may be briefly summarized as follows:

(1st) To determine the relations between the different rock formations at or near the surface of the earth and prepare reports, maps and drawings, giving the thickness, surface distribution, relation to other formations, structure and characteristics of each formation.

(2d) To investigate and publish reports on the economic resources of the state; which include lead, zinc, coal, oil, iron, copper, barite, building stone, clays, cements, road materials, soils, water, etc.

(3d) To collect, name and arrange a cabinet which shall include specimens illustrating the geology and economic resources of the state; also to assist the colleges and schools of the state to make similar cabinet collections.

(4th) To examine ores, rocks, soils and other earthy substances with which the citizens of the state may not be familiar. That is, the Bureau of Geology and Mines should be a department to which a citizen of the state may apply and receive reliable information as to the kind and value of any mineral which he may discover.

(5th) To disseminate, everywhere, correct ideas as to the occurrence, origin and relation of ores, minerals and rocks, with the end in view of increasing the general intelligence of the public on matters related to geology and mining. The Department should be a Bureau of Information to which the outside world, seeking investments, can apply and receive trustworthy information concerning geology and mining in the state.

(6th) To co-operate with and not duplicate the work of the United States Geological Survey. Not only should the Bureau co-operate with the United States Geological Survey, but it should also work in conjunction with the Bureau of Soils, the Bureau of Forestry, the Bureau of Highways and the Bureau of Hydrography. If properly organized, the department should have on its staff men who understand the value of different soils, waters, forestry conditions and road materials as well as geology. Topographic, hydrographic and soil surveys are as truly a part of the work of a Bureau of Geology and Mines as geological and mining investigations.

It is doubtful if it should ever be the province of the Bureau of Geology and Mines to examine and report on individual or private mining properties, except as they constitute a part of a larger report covering the region in which the mine may be located. This is practiced, more or less, it is true, by all Geological Surveys. Yet there is a field for the professional Mining Geologist and it seems that there the Geological Survey frequently oversteps its legitimate field. The investigations of Geological Surveys should cover *districts, regions or counties,* and should not be limited to individual or corporation mining properties.

It is also questionable whether the Bureau should ever make free assays or analyses of minerals, ores, clays or rocks for individuals or corporations. It is frequently necessary for the Bureau to make analyses and assays in the preparation of reports on the economic resources, or even in the progress of the county surveys, and for such work a chemical laboratory is required. There is a field for the professional analyst and assayer, and when the state provides a free assay office, it is encroaching upon the legitimate field of this profession.

Some who have given little attention to geology complain that the reports of the Bureau of Geology and Mines and Geological Surveys contain terms which are technical and obscure; that the publications are unintelligible and consequently of little or no value. It must be recognized, however, that this is not a defect of the reports, but rather of the individual, who apparently is not willing to begin with the elements of the science and work up to a point where he can read intelligently, geological literature. Every time a mathematician writes an algebra he cannot preface it with an arithmetic, although arithmetic is necessary for an understanding of algebra. A person who publishes a novel cannot accompany it with a dictionary. It is supposed that the reader's earlier training will have given him a sufficient vocabulary to make the novel intelligible. Likewise a physicist writing of "Dynamos" cannot preface his book with an elementary treatise on electricity. If a man has use for the text book on dynamos, he will familiarize himself with the elements of

the science before attempting to study the more advanced treatise. If men have not time or sufficient interest in the problems discussed in Geological Survey reports to first acquire the elementary principles necessary to read them intelligently, they ought at least not to condemn the reports for lacking that which they themselves should have acquired elsewhere.

It may be the duty of the Bureau of Geology and Mines to provide a series of reports dealing with the elementary principles of Geology and Mineralogy. In fact, I believe that such a set of reports, taking the place with the public that the primer does with the public school, would very greatly enhance the value of the more or less technical reports of the Bureau of Geology and Mines. Such a set of reports, in which the illustrations were drawn from Missouri, could be used to advantage in the public schools, increasing very greatly the students' knowledge of the physical geography and economic resources of the state in which they live.

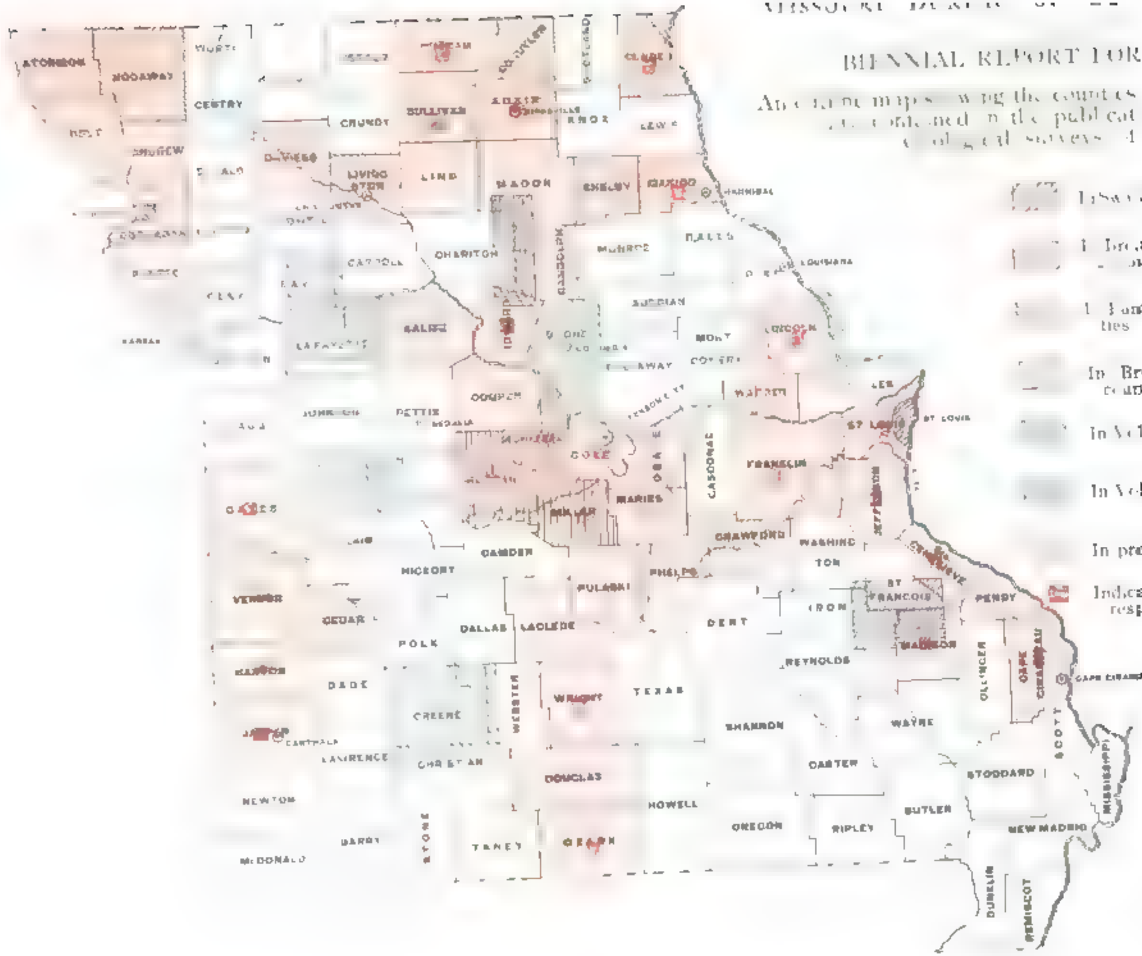
Because the geologist connected with a Geological Survey does not attempt to locate ores, as does the prospector, and because he confesses his inability to see a thousand feet beneath the surface of the ground, his work is often condemned. If he cannot tell you what lies beneath the surface, simply by walking through the fields or riding along a road, he is classed among the incompetents. Bear this in mind: "No man, whether he be miner, engineer or geologist, can give an intelligent opinion of the resources of a given territory without first spending days, weeks and sometimes months in examining the hills and valleys with their outcroppings of rock." It sometimes happens that he can then only tell you whether or not the evidence warrants the expenditure of money in prospecting by digging or drilling. From the drill records he will undoubtedly be able to tell you whether or not the contents of the strata are such as to warrant opening a mine.

The scientific geologist whose knowledge comes from years of observation on the occurrences of ores in all kinds of mines and under all conditions may be conservative but he is safe. He will discourage speculative enterprises in which the evidence does not warrant investment and will direct capital into channels where there is a greater probability of success. Unwarranted speculation in mining or any other business may benefit the few, but the community or state at large will surely suffer by the inevitable reaction.

The Bureau endeavors to keep as close as possible to the facts and upon these alone do we base our judgment of the mineral prospects of an area upon which we may be called to pass judgment.

BIENNIAL REPORT FOR 1901-02, PL. II.

Areal map showing the counties of which special reports are contained in the publications of the earlier geological surveys of the State.



In Swallow's Report of 1855, 5 counties.

In Broadhead's et al. Reports of 1871, ... counties.

In Pumpelly's Report of 1872, 8 counties.

In Broadhead's Report of 1873, 1- counties.

In Vol. XII

In Vol. IX

In preparation.

Indicates that maps are printed of the respective counties 26 counties.

COUNTY REPORTS.

There are sixty-three counties in Missouri for which reconnoisance or complete geological reports have never been published. Eleven of these have been reported upon in part in the earlier publications of the Bureau, but for fifty-two of the counties there are no published reports. This situation may be attributed very largely to the disconnected, interrupted life of the Bureau brought about by changes in administration.

The accompanying map (Plate II) will give the reader an idea of the area which has been covered by the earlier surveys.

Under the present administration it is the plan to begin a thorough, detailed survey of these counties, publishing reports on each as soon as the manuscripts, maps and drawings can be prepared. These reports will consist of descriptions of the rock formations and mineral resources; geological map of the county; drawings showing the vertical succession of the beds and cross-section showing the structure of the region; and photographic illustrations of typical rock exposures. The descriptions of the formations and mineral deposits will be made in sufficient detail to be of assistance to the prospector in locating and working ore bodies.

The nature of these reports can be better understood by an examination of the following brief outline of the report on Miller county, which is now in press:

The Areal Geology of Miller County.

I.—Introduction.

(A) Area.

1. Location.

(a) Latitude and longitude. (b) Geographical position. (c) Position and relation to Ozark Uplift. (d) Position with respect to Lead and Zinc districts.

2. Size and shape.

(a) Length and breadth. (b) Number of square miles. (c) Relative size.

(B) Aim and scope of work.

(C) Methods of field work.

(D) Acknowledgments.

II.—Bibliography With Resume of Work.

III.—Physiography.

(A) Types of surface relief.

1. River bottom land areas.
2. The broken or hilly areas. (1, Brakes. 2, Ridges.)
3. The uplands, prairies, or table land areas.
4. The relation of physiographic types to industrial and social conditions.

(B) Caves and sinks.

1. Recent.
2. Ancient.

(C) Relative elevations.

(D) River Systems.

1. The Osage.
   (a) Drainage area. (b) Direction of flow. (c) Amount of fall. (d) Volume. (e) Character of valley and flood plains. (f) Fords. (g) Tributaries.
2. The Moreau.
   (See sub-letters under (1) above.)

(E) Divides.

IV —Stratigraphy.

(A) Undifferentiated Cambrian and Ordovician.
Proctor Limestone. (Fourth Magnesian Limestone of Swallow.)

(B) Ordovician.

1. Gunter Sandstone. (Third Sandstone of Swallow.)
2. Gasconade Limestone. (Third Magnesian Limestone of Swallow, in part.)
3. St. Elizabeth Formation. (Includes Second Sandstone of Swallow and also part of Swallow's Second and Third Magnesian Limestones.
4. Jefferson City Limestone. (Second Magnesian Limestone of Swallow, in part.)

(C) Devonian (probable Sac Limestone).

(D) Carboniferous.

1. Lower Carboniferous.
   (a) Upper Burlington Limestone. (Lower Beds.)
2. Upper Carboniferous.
   (a) Graydon Sandstone. (b) Coal Measure Shale. (c) Coal.

(E) Pleistocene.

1. Glacial boulders.

(F) Recent.

1. Soil.
2. Travertine.

(G) General section.

V.—Geological Structure.

(A) Folding (Ill. By Cross section).

(B) Faults (Ill. By Cross section).

(C) Unconformities (Ill. By Cross section).

1. Proctor-Gunter.
2. Upper Burlington.
3. Graydon Sandstone.
4. Coal Measure shale.
5. Recent.

VI.—Geological history.

VII.—Minerals and Rocks.

VIII.—Economic Geology.

(A) Lead and zinc; (B) Barite; (C) Coal; (D) Building stone; (E) Lime; (F) Cement; (G) Sand; (H) Clays; (I) Road materials; (J) Iron; (K) Gold and silver; (L) Copper; (M) Oil and gas; (N) Soils; (O) Water supply.

IX.—Resume and Conclusion.

The present published Geological Map of Missouri was compiled from surveys of about one-half of the counties in the State and necessarily contains many inaccuracies. It has been broadly generalized and the distribution of many of the formations is very inaccurately outlined. One of the results of the survey of the counties will be the preparation of accurate geological county maps, from which in due time a reliable state geological map can be constructed.

During the last year one county was entirely, and two more were partly, surveyed. The preparation of the county reports, exclusive of topographic maps and printing, will cost all the way from $1,200 to $2,500, depending upon whether the geology is simple or complex. Five or six counties should be surveyed each year and an adequate appropriation made therefor. If the present policy of the survey is carried out this work in the end will cost the state about $150,000. One-fifteenth of this should be appropriated each year for fifteen years and a consistent policy maintained by which each county will be eventually surveyed and reported upon. It is unnecessary to enumerate the states where this work was done ten or fifteen years ago or call attention to the states that are now engaged in this undertaking. Pennsylvania and Iowa are two well known examples. In the former state, reports have been made covering all the counties. In the latter state only about two-thirds of the counties have been reported upon and the work is being carried steadily forward.

The order in which the counties are surveyed should be left entirely to the discretion of the Board of Managers, and each representative and

senator should assist in this work with a knowledge that his county will eventually receive the same attention as the other counties which are now being surveyed.

SPECIAL ECONOMIC REPORTS.

The second function of the survey, mentioned above, was the investigation and reporting upon special resources, such as coal, lead and zinc, barite, building stone, clays, cements, road materials, etc. Reports of this nature are represented by the volumes of this Bureau on "Lead and Zinc," "Coal Deposits," "Clay Deposits," "Iron Ores" and "Mineral Waters." The demand for these reports has been so great that the editions of all these reports have been exhausted. There are constant requests from all parts of the country for these reports, yet we have none with which to supply the demand. Some of these volumes should be rewritten and a new edition published, if it is expected that this department shall do its utmost to interest the outside world in the rich mineral resources of the state. Logically, these reports should follow the completion of the county reports, but so long have these areal reports been delayed and so great is the demand for the economic volumes, that this department must devote a part of its funds to the preparation and publication of economic reports.

The revision and republication of the reports on "Lead and Zinc," the "Clay Deposits" and "Coal" would meet a very strong present demand for information on these resources.

Besides the republication of these reports, new special reports should be issued on "Barite," "Pyrite," "Cements," "Road Materials' and "Solis." These subjects should be investigated in all sections of the state and the results of these investigations published. In this way information can be gathered and disseminated which can be obtained in no other way.

During the last year the Bureau has begun the investigation of the "Quarrying and Building Stone Industry," and, if nothing unforeseen occurs, a report on this subject will be ready for distribution sometime during the next year. The following is a brief synopsis of this report:

The Quarrying Industry of Missouri.

I.—Introduction.

II.—Demands and uses for stone.

(A) Constructional Work.

(1) Building; (2) Street constructions; (3) Monuments; (4) Bridges and culverts; (5) River and lake shore constructions; (6) Railroad ballast; (7) Black boards, sanitary wares and tables; (8) Miscellaneous.

(B) Manufacturing.

(1) Cement; (2) Quick lime; (3) Carbon dioxide; (4) Abrasives and polishing powders; (5) Flux; (6) Gannister; (7) Miscellaneous.

III.—Necessary Considerations in the Selection of Stone for these Various Purposes.

(A) External causes of decay.

(1) Agents promoting mechanical disintegration. (2) Agents promoting chemical decomposition.

(B) Inherent qualities of the stone.

(1) Mineralogical composition.
(2) Chemical composition.
(3) Texture.
(4) Hardness.
(5) Strength.
(6) Structure.

IV.—Methods of Determining the Value of a Stone for Building or Other Economic Purposes.

(A) Quarry observations.
(B) Observations on buildings, monuments, pavements, etc.
(C) Laboratory tests.

(1) Chemical.
(2) Microscopical.
(3) Physical.

(1) Crushing strength. (2) Transverse strength. (3) Elasticity. (4) Specific gravity. (5) Porosity. (6) Weight. (7) Effect of freezing and thawing. (8) Effect of acids.

V.—Description of the Granite and Porphyry Areas and Quarries.

VI.—Description of the Sandstone Areas and Quarries.

VII.—Description of the Limestone Areas and Quarries.

VIII.—Areas from which Suitable Stone for Different Uses May be Obtained.

IX.—Discussion of the Results of the Physical Tests on Stone from Missouri Quarries.

X.—Minerals and Rocks. Different Kinds and their Composition.

Economic reports similar to the above cost for field work and publication, various amounts depending on the importance of the industry. The cost will probably range from $3,000 to $10,000.

COLLECTING CABINET SPECIMENS.

The third function of the Bureau is to collect, name and arrange a collection of specimens illustrating the geology and economic resources of the state. Somewhere in the state there should be a collection of the ores, minerals, rocks and fossils of Missouri, to which the public may have access and which represents truthfully the state's clay, stone and mineral resources. There is no department better equipped for making this collection than the Bureau of Geology and Mines. This collection may be made incidentally as the field work for the various reports is being carried on.

The collection now in the Bureau is only a fair representation of the mineral resources of Missouri. The industrial side of the exhibit has not been strongly enough emphasized. It is intended during the coming years to make this feature of the Cabinet more prominent. It is our purpose to have in this cabinet collections of ores from all the mining camps in the state; clays and clay products from all the brick, tile and terra cotta plants; building stone from all the quarries; cements from all the cement factories; and quick lime from all the lime kilns. It is not intended to make this a collection of oddities, in the way of beautiful or peculiar crystal growths, but to make it a commercial exhibit which will be of interest to the miner, investor and educator. It is our purpose to put the collection in such shape that people, who are not able to visit all the mines, may view this collection with an understanding that they will see fairly exhibited the mineral resources of the state. The specimens contained in the exhibit will be the ordinary and not the exceptional products of the mines. It is intended that these exhibits shall be accompanied with maps, charts and reports, which may further assist the investor and student in obtaining a knowledge of the resources of this commonwealth.

During the process of collecting, many duplicate specimens may be, with little additional trouble, collected and used for making up type sets of specimens to be sent to the colleges and prominent high schools of the state. I believe that it would be within the province of this Bureau to employ a man during the year to collect and prepare sets of specimens for this purpose. Some of the higher institutions of learning are woefully deficient in this kind of material for the use of classes in geology and physical geography. All of these functions cannot be performed with the very limited appropriation which has been allotted to the Bureau in the past. For this work, however, I believe some provision should be made.

CARD CATALOG RECORD CASE NO. 1.

EXAMINATION OF SPECIMENS.

Many of our citizens are unfamiliar with the appearance of the common ores which occur abundantly in some sections of the state. They may frequently pass by a deposit of zinc blende or even galena without recognizing its value. It is one of the duties of this Bureau to examine all specimens sent to it by citizens of Missouri furnishing such information as it can relative to the kind and value of the mineral. It would be very desirable for the Bureau to make free analyses and assays of specimens, if it were not for the fact that this privilege would be greatly abused and that it is an infringement upon the field of the professional assayer and analyst. The Bureau should furnish advice as to whether the specimens submitted are of such a nature as to warrant an assay, but the determination itself should be left to the professional assayer.

In connection with the preparation of reports on economic resources and areal geology, there are a great many analyses of rocks and ores necessary. For this purpose the Bureau should be provided with its own laboratory. Important determinations can be made more carefully, are more reliable and cost less than when they are made in other laboratories. If the Bureau has a well equipped laboratory, the cost of making assays and analyses would be comparatively little.

The Bureau is not at the present time provided with a chemical laboratory, but it is hoped that within a year or two the necessary equipment will be provided.

BUREAU OF INFORMATION.

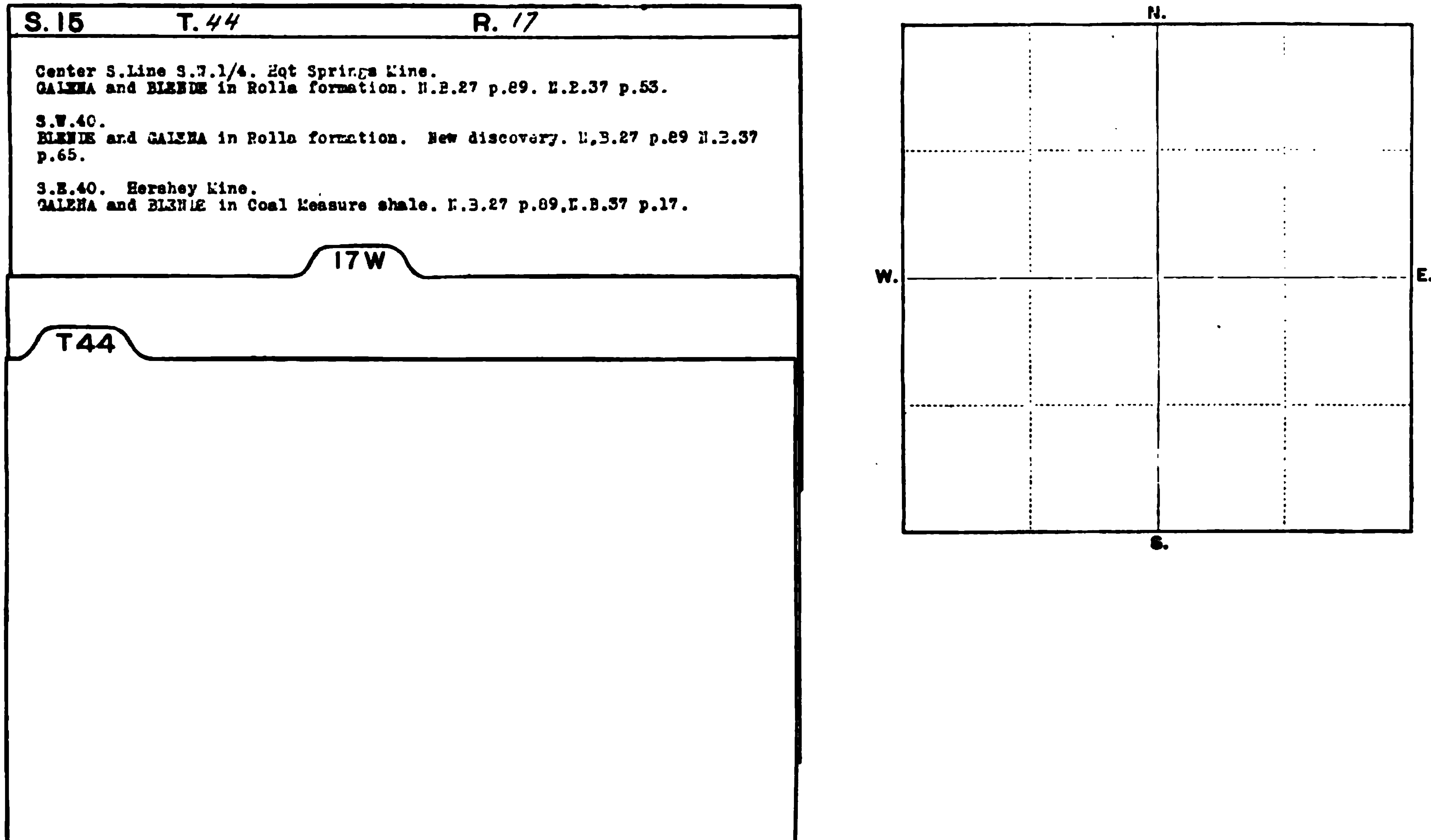
In order to give out information, it must first be collected. When collected, it must be stored away for future use. The value attached to such information depends very largely upon the ease with which it can be obtained when wanted. A Chicago gentlemen, interested in mining land in Sec. 7, T. 32N., R. 28W., writes to the Bureau and asks for such information as we have bearing upon the mineral resources of the above described land. Another gentleman writes for information concerning lead in Shannon county (R's. 3W to 6W., T's. 26-29, R's 2W., T's. 28 and 29, and R. 1W., R. 28.) These illustrate the two classes of inquiries which are continually coming to the department for replies. Information which will assist in answering these inquiries is also constantly coming to the Bureau through correspondence or through personal investigations by members of the Bureau staff. The question which presented itself to

the Director upon taking charge of the Bureau was, how to devise a plan for classifying and storing this information for future use. It was recognized that in any case the process of accumulating the necessary information would be slow and years might elapse before the records would very greatly assist in answering inquiries similar to those mentioned above. Nevertheless it was believed that a beginning should be made.

As a result of much thought and planning a combination note book and card catalogue system was adopted. The note books adopted are of two kinds, designed for areal and economic work. These books are numbered consecutively and the pages are also numbered. In these books are recorded, in ink, the observations taken while in the field. The observations are necessarily of a miscellaneous character and are arranged in the books in the order in which they are made. One page may contain notes on coal found in Sec. 5, T. 52, R. 18E., while the opposite page may contain a discussion of lead or zinc in Sec. 16, T. 44, R. 17W. These note books accumulate from year to year, but no mind can keep track of the information which they contain or the page of the note book in which it occurs. At least no one on the staff but the man who recorded the information knows where to find it. There are in the Bureau to-day several hundred note books containing observations on the geology and economic resources of the state which, on account of the time it would take to glean special information from them, are almost valueless.

That the information collected may be preserved and transmitted to succeeding administrations, the card catalogue has been introduced. To keep this information in such shape that all questions similar to the above—one about lead and zinc in a township or county and the other about the mineral resources of a particular section or tract of land—can be answered quickly and accurately, two separate cases have been provided. These cases are shown in the accompanying illustration and will be described separately.

The first case (Plate III.) contains sixteen drawers or trays. Each of these are labeled with the numbers of certain townships. For example, the label on the upper left-hand drawer reads, "Townships 16 to 21;" the one below that, "Townships 22 to 24;" and so on, as shown in the figure. In each of these drawers are white cards five by eight (5x8) inches in size, on which is recorded the information which it is intended to preserve. Besides these cards are others having a yellow color and still others which are blue. The yellow cards have numbers on them corresponding to the numbers of the townships on the outside label and are placed in ascending order from the front to the back of the tray. Between the yellow cards there are from 35 to 52 blue cards with numbers



RECORD CARDS USED IN CASE I.--FRONT AND BACK OF CARD.

marked on the tabs referring to all the different ranges in which the town, indicated on the yellow tab, occurs in Missouri. Back of the blue cards are inserted the white cards, one for each of the 36 sections in a township. These cards are shown in the accompanying illustration, Plate IV.

Should information be received that lead had been found in the S. W. ¼ of the N. E. ¼ of Sec. 26, T. 38, R. 20W., there would be recorded on the card for this section, briefly, all the information at hand, giving the authority and the date. If the information was collected by a member of the survey and recorded in a note book, the same summary of the occurrence would be made on the card, but, in addition, the number and page of the note book would be recorded. On the back of each card is a diagram representing a section of land, and here the location of ore is indicated by a symbol.

Where the information is stored in this way an inquiry as to the mineral resources of a given section of land can be answered in the space of a few seconds, while it might take hours to find the desired information if one were compelled to look through records, as kept in field note books.

The second case also contains sixteen drawers or trays carrying cards six by four (6x4) inches in size. By glancing at Plate V. it will be observed that each of these trays has a distinct and separate label. One tray is marked "Clay," a second "Lead and Zinc," a third "Coal," etc. All information concerning these various resources, coming to this office, is filed in one of these trays. These trays contain one set of record cards and another set of tab cards. A set of tab card consisting of one for each county is included in each tray. A record card is used for each section of land in the county, and in the tray there are placed back of each county tab card as many cards as there are sections of land in the county. The memorandum is recorded on these cards, but it is usually briefer than that on the cards of Case I. The notes are often made to refer back to Case I, as well as to the note books. The value of this case comes from having in a separate tray all the information collected bearing upon each of the mineral resources of the state. The cards used in this case are shown in the accompanying illustration, Plate VI. By referring to this case one can answre in a few moments any inquiry for information on the lead deposits of Dent or any other county, provided such data have ever been collected.

These two cases provide the Bureau with the most efficient and practical system of keeping a record of the resources of the state that has yet been devised.

It may be well to state that it is not expected that these card record cases will be of any more than occasional value for several years. Each year, however, as information is stored away in them, they will increase in value. For the next ten years they will constitute reservoirs, or the houses, wherein the grain to be used in future years will be stored. A record of this kind, carefully preserved, will eventually be invaluable to the citizens of Missouri, where the mineral resources are of such a diversified character.

This card record system has been extended into other departments of the Bureau. A case with nine trays, carrying cards three by five (3x5) inches in size, has been provided for keeping a record of all publications received and distributed by the Bureau. The publications of the Bureau are sent to all parts of the world, and from all countries we are receiving scientific publications in exchange.

On the front and at the top of the cards used in this case is written the name of the state or country, the name of the city and the name of the person or organization to which the bureau publications are sent. On the lower half of the card is a list, by number, of the reports which have been published by the Bureau and a list of those which will probably be issued during the next ten or fifteen years. A cross drawn through any number indicates that this volume has been sent to the address written on the card. On the back of the card is a record of the volumes received from the individual or society whose name appears on the front card. This system of recording exchanges enables us to keep a record of all reports distributed, with the name and address of the party to whom sent, and also a record of all publications received in exchange.

Another four-tray card record case, with cards four by six inches, is used for keeping a permanent inventory of stock and the accounts of the Bureau. The stock of the Bureau is classified as permanent and temporary. In the first class are included desks, chairs, cabinets, instruments, etc. In the second are included note books, stationery, chemicals, etc. The permanent stock is distributed through the building, in the library, museum and offices. Each article in a room is charged against that room, and the person to whom the room is assigned is responsible for the furnishings and instruments in that room.

The money appropriated for the maintenance of the Bureau is expended in general in three directions: (1) for salaries, (2) for traveling expenses and (3) for supplies. A record of the amounts expended for these purposes is kept on separate cards, and it requires only a few min-

CARD CATALOG RECORD CASE NO. 2.

utes for one to ascertain the amount which has been expended in all or any one of these directions.

Cards are also kept which show the amount which has been drawn by each member of the Bureau for each of these purposes. Accounts are also kept with various manufacturing concerns and local companies from whom supplies are regularly purchased. Accounts are also kept with instruments, stationery, furniture, etc., so that one can ascertain very quickly the amount which has been expended for each of these purposes.

Before the records of the Bureau are complete, two more card cases must be provided, one for a record of the cabinet specimens in the museum and the other for cataloging the books and pamphlets in the library. Every specimen should have a number and every book should be lettered and numbered. The location of specimens and books in the cases or on the shelves should be recorded on the card with which they are catalogued. The photographs, plates, cuts, maps and everything else should be thus indexed.

It is our purpose to obtain these additional cases and continue the cataloging as rapidly as time and money will permit. After they are finally in shape, they can be maintained easily and at a moderate expense.

The time which will be saved to the members of the Bureau will many times compensate them for the trouble and pains necessary to keep the system up. It would even be profitable to employ a stenographer especially for this work, if it could not be carried on by the stenographer who does the general work of the office.

The above discussion has carried us somewhat away from the Department as a Bureau of Information, but the entire card record system is so intimately connected that one part cannot well be discussed without the other.

Upon any subject that pertains to the organization or work of the Bureau, whether it be a record of drill holes in St. Francois county or a record of the accounts for December, the card system places us in a position where we can answer inquiries quickly and accurately.

CO-OPERATION WITH THE U. S. GEOLOGICAL SURVEY.

It is the policy of this Bureau to co-operate with and keep in close enough touch with the U. S. Geological Survey to know what work is contemplated for Missouri, so that there will be no chance for duplication. This year there has been expended by the U. S. Geological Survey, in geological and topographical work in Missouri about $8,000, or a sum nearly equal to that appropriated by this state for geological work for the same period. Five thousand dol-

lars of this has been spent in a geological investigation of the Joplin district, and the other three thousand in making a topographic map of the so-called Versailles sheet, which includes a portion of Morgan, Miller, Camden and Moniteau counties.

An idea of the importance of co-operation between the state and United States Surveys will be obtained by reading the following extracts quoted from the twenty-second annual report of Dr. Charles D. Walcott, the Director of the United States Geological Survey:

"Under terms varied to suit the conditions of each special case, agreements involving co-operation of some sort have been made between the Director and State officials of Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, West Virginia, North Carolina, Georgia, Alabama, Ohio, Wisconsin, North Dakota, Colorado, Nevada, Idaho and Arizona."

"The States benefit by co-operation in geology and allied scientific activities by the resulting reduction in expense of administration and the possibility of a specialization in detail otherwise unobtainable."

"The Federal Bureau benefits by the great increase in funds available for the extension of its legitimate operations. This Bureau is charged with the duty of making a topographic and geologic map of the entire area of the United States, as well as of studying its water resources and reporting on its other economic products. The expense of this work to the Federal Treasury is reduced by the amount appropriated by the varioue States for co-operative surveys. All agreements for co-operation being on the basis of equal expenditure, they necessarily reduce by one-half the cost to the Federal Government of conducting its operations. An additional benefit of co-operation is the hastening of the completion of the topographic map, which thus renders it available at an earlier date as a base for the further studies of economic resources—geology, hydrography and the classification of lands."

"One important point to be considered in all such work is that the general plans and methods of the Federal Survey can not be set aside on account of State co-operation. At the present time the funds available for co-operation are so limited that its further extension is dependent upon increase of appropriations by Congress. It is against the policy of the Survey that work on important areas or subjects should be stopped in order that co-operation with individual States may be extended. The Director is willing to enter in a co-operative agreement only when the interests of the country as a whole will be benefitted."

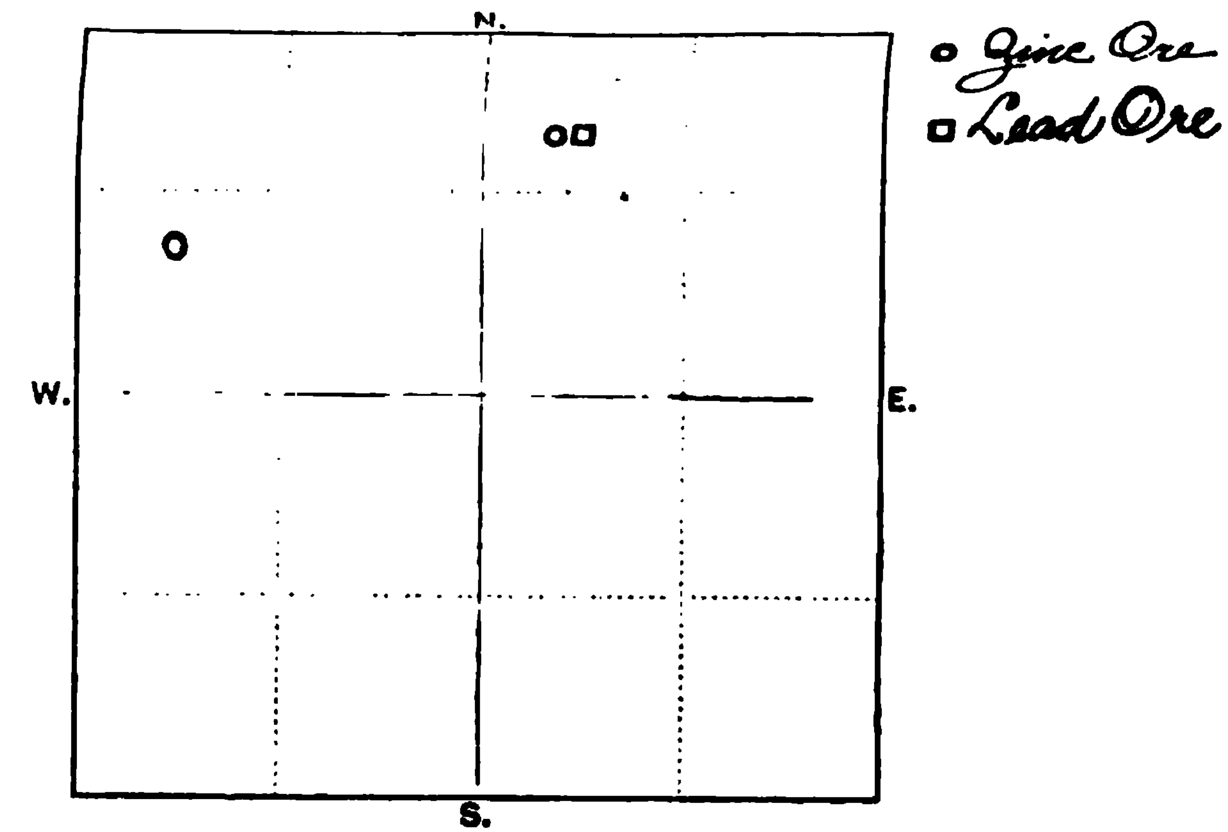
"The total cost of mapping the State of Massachusetts was $107,845. This is exclusive, however, of much of the primary triangulation, which

S. 3 T. 41 R. 16

N.CENTER of S.W.1/4 of N.W.1/4
BLENDE in Coal Measure shale; shines. N.B.33,p.29.

S. CENTER N.W.1/4 of N.E.1/4.
GALENA and BLENDE in Coal Measure shale pocket. N.B.2b,p.
17. N.B.33,p.9.91. N.B.32,p.97.

T41



RECORD CARDS USED IN CASE 2, SHOWING FRONT AND BACK OF CARD.

was executed by the United States Coast and Geodetic Survey. The total average cost of this work was at the rate of $12.90 per square mile." * * * "The total expense of making the topographic survey of New Jersey was $54,744.58. Of this sum the United States Geological Survey expended $35,073.98. The total cost of mapping the State was at the rate of $6.93 per square mile, exclusive, however, of three-fourths of the primary triangulation, which had been previously executed by the United States Coast and Geodetic Survey." * * * "Co-operation with the State of Pennsylvania was commenced in the year 1899 by the appropriation for the two years, 1899-1900, of the sum of $40,000, which has been expended under the supervision of the State commissioners, George W. McNees, Simon Harrold and F. D. Barker." * * * "Co-operation with the State of North Carolina was commenced during the current year by the allotment of $20,000 for the two years, 1901-1902, by Governor Charles B. Aycock from the funds of the State agricultural commission." * * * "Co-operation with the State of West Virginia was commenced during the current year as a result of the appropriation by the last legislature of the sum of $30,000 for the two years, 1901-1902."

"The appropriations made by the States for co-operative surveys are accepted only for actual field work, in which are included the services of temporary employees, who are usually residents of the State, and the living and traveling expenses of the field force. Thus the amount appropriated by the State is returned to the people thereof. The appropriation of the Federal Government is devoted chiefly to paying the salaries of the permanent employees, a small portion of it being expended on general administration and a considerable portion on field and office work. The field work of the co-operative topographic surveys is invariably in charge of topographers or assistant topographers of the United States Geological Survey, who are appointed, on the recommendation of the United States Civil Service Commission, by the honorable Secretary of the Interior. All assistant surveyors, as levelmen, transitmen, etc., and such helpers as rodmen, teamsters and cooks, are employed, under regulations of the Department of the Interior, in the locality in which the work is being done and under the terms of a signed application and agreement, which they must file when seeking such employment."

"The topographic map is the base upon which the field investigations of the geologists and hydrographers are recorded, and which makes possible a broader and more general study of the results than is otherwise practicable. It was at once realized by State officials to whom such investigation had been assigned that an accurate and comprehensive performance of their duties was impossible without an adequate topographic base map. The expense of making such maps, however, was found to

exceed in most instances the resources procurable from state aid, and the lack of skilled men required in making such surveys was a barrier not easily surmounted. Competent topographers are rare, and there is little inducement for young engineers of ability to make this their profession outside of the work of the General Government while there is so little opportunity for steady employment elsewhere. By co-operating with the Federal Survey it was apparent that the opportunities for systematic mapping would be greatly increased in the States availing themselves of the personnel and administrative knowledge of the Survey."

"Accordingly, the first important step in the development of the existing system of co-operation was in connection with the extension of topographic mapping. The benefits to the State from co-operation are numerous. It gains a complete topographic map of its area, which is of importance to the development of its numerous economic resources and greatly facilitates the study and perfection of all engineering plans and works. Among other uses of the topographic maps are the following:

1. EDUCATIONAL.—(a) By promoting an exact knowledge of the country; (b) by serving teachers and pupils in geographic studies.

2. PRACTICAL.—As preliminary maps for planning engineering projects. Highways, electric roads, railroads, aqueducts and sewerage plants may be laid out on them, and the cost of preliminary surveys may be saved. Areas of catchment for water supply, sites for reservoirs and routes of canals may be ascertained from these maps.

3. POLITICAL.—In all questions relating to political or legislative matters. For these purposes they afford accurate information as to the relations of boundaries and towns to natural features.

4. ADMINISTRATIVE AND MILITARY.—In all questions relating to Federal or State administrations of public works, as canals, reservations, parks, highways and as military base maps on which to plan works of offense, defense, camps, marches, etc.

5. STATISTICAL.—As base maps for the graphic representation of all facts relating to population, industries, products or other statistical information.

6. ECONOMIC.—As a means for showing the location, extent and accessibility of lands, waters, forests and valuable minerals. In this respect these maps are indispensable to State and Federal bureaus, and to owners, investors and corporations.

In addition, as an incident in the making of a topographic map, monuments are established throughout the State, the positions of which are accurately determined by geodetic methods and which serve as datum points for all other Government, private and cadastral surveys. There are also established throughout the State bench marks or permanent

monuments which furnish datum elevations for the future determinations of height in connection with all public or private engineering works. Meridian marks are established at each county seat, which aid local and county surveyors in determining the declination of their compasses and which thus greatly facilitate the search for old property lines."

"The maps that result from these co-operative surveys show, in different colors, both in the manuscript and in the published edition, the following principal facts:

1. Public culture, printed in black, which includes the exact plan of every road, lane, path, railroad, street, dam, public boundaries, names, etc.

2. The hydrography, or water, printed in blue, including all lakes, rivers, streams, swamps, marshes, reservoirs, springs, etc.

3. The relief, or surface forms, printed in brown, including the shapes of the hills, valleys and ravines, their elevations and depressions, and the slopes of every rise or fall in its surface of the land.

The topographic maps produced by co-operative surveys are engraved on copper and printed from stone. The co-operating States have the benefit of this publication without further expense, and the residents of the State, as well as its officials, may purchase the maps at rates of 5 cents per sheet or $2 per hundred."

Co-operation should extend beyond the United States Geological Survey and include the Bureau of Soils, the Bureau of Forestry, the Bureau of Highways and the Bureau of Hydrography. The work of all of these Federal bureaus is valuable and their attention should be directed to the state of Missouri. A soil survey by the United States Bureau of Soils was begun last season in the southern part of the state. A little assistance or encouragement in this work by the Bureau of Geology and Mines might induce the department to continue indefinitely this survey. The other Bureaus have done very little work in Missouri. Correspondence with the Department of Hydrography leads me to believe that before the end of next season stations for taking hydrographic observations will be established.

RELATION TO SCIENTIFIC ORGANIZATIONS, THE UNIVERSITY, ETC.

This Bureau should not only direct its attention to the development of the mineral resources of Missouri, but it should also interest itself in the dissemination of Geological and other Scientific information which may lead to a better understanding, on the part of the people, of the geography and geology of the state. The scientific and engineering societies

of St. Louis and Kansas City ought to be interested in the work of the Bureau and the Bureau ought, in turn, to assist in sustaining these organizations.

Much can be done to aid the work of the Bureau by the Business Men's organizations of such places as Joplin and Aurora through friendly and social intercourse between the members of each organization. These clubs can assist the Bureau very greatly in its work in the districts in which they are located and the Bureau can undoubtedly, in a measure, contribute to the success of their mining enterprises.

There are many men in the state, some of whom are members of local scientific societies, who have a deep interest in the scientific work of the Bureau. These men can aid the Bureau very greatly in the communities in which they live, and they can rest assured that the Bureau will always be glad to assist them to any information which it may possess.

It is hoped that the Bureau may be able to avail itself of the service of the young men graduating from the University and School of Mines, who have had special training in geology and mineralogy. However, it requires a thorough knowledge of geology and mineralogy, in its many branches, to fit a person for an assistant's position in the Bureau. The state should provide abundantly for the training of young men along these lines so that it will not be necessary to employ men from other states. Thus far the Bureau has employed all the different men from the University and the different colleges of the state, who have had the necessary training, to perform the duties of field assistant. It is of mutual advantage to the Bureau and the University to have men employed in the work of the Bureau who have been trained at the University of Missouri.

PETITIONS.

The forty-first general assembly amended Chapter 110 of the Revised statutes of 1899 by adding the following new section, known as section 7503b:

"Section 7503b. On presentation of a petition to the state geologist, signed by not less than fifty freeholders who reside in the neighborhood of lands situated in any county in this state which they may believe to contain valuable or have found valuable ore, clays, rocks, coal, mineral, oils or mineral matter, said petition being certified by the clerk of the county court in which the petitioners reside to contain the names of fifty freeholders residing within the neighborhoods of the lands, which lands shall be described in the petition according to government surveys, is shall be the duty of the state geologist in person or by assistant, as soon as practicable to examine and inspect said lands and make a report

and map as to existence on said lands of valuable ores, clays, coals, mineral, oils or mineral matter found and embody the same in his report now directed to be made by section 7503, Revised Statutes of Missouri, 1899."

In compliance with these instructions the State Geologist has answered in person all petitions for the examination of mineral lands and furnished to the parties interested a written report covering the results of such examinations. As far as time would permit the State Geologist has also answered requests, which were unaccompanied by a petition, for an examination of mineral lands. In these cases the parties making the request were required to furnish satisfactory evidence that there was a reasonable expectation of finding mineral.

The petitions, as a rule, came either from local companies or from communities interested in prospecting for oil, coal, lead and zinc, or in developing stone quarries. The following is a list of the petitions received and copies of the answers returned under the present administration:

PETITION OF J. W. GRAYSON ET AL., NEWBURG, MO.

Petition to examine following described lands: S. ½ S. E. ¼ of sec. 33, T. 37, R. 9 W; the N. E. ¼ of the N. E. ¼ and the N. W. ¼ of the N. E. ¼ of sec. 4; the S. W. ¼ of the N. E. ¼, S. E. ¼ of the N. W. ¼ N. W. ¼ S. E. ¼ of sec. 3, T. 36, R. 9 W.; and the S. ½ N. W. ¼ and S. W. ¼ of N. E. ¼ of sec. 36, T. 37, R. 9 W.

To the above petition the following report was submitted:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF NEWBURG.

In response to a petition, signed by J. W. Grayson and 72 others, I visited the land above described, making an examination of the different prospects and studying the relation of the various formations of that region. The examination of the lands was made in company with John A. Chambers and J. L. Buskett.

The strata which outcrop in this area consists mainly of what have been known as the Second Saccharoidal Sandstone, and the Third Magnesian limestone. A large part of the ridge lands of this area are covered with soil which is underlain by chert or sandstone beds of the Second Saccharoidal Sandstone formation. As near as could be determined from aneroid barometer measurments, the sandstone formation is about 140 feet thick. The aneroid barometer indicated that the bottom of the sandstone formation was normally about 160 feet above the level of Little Piney River at Newburg. In some places, however, the sandstone occurs at a much lower horizon, coming in somewhat abruptly along the sides and heads of some of the draws. In one instance, sandstone was observed

on one side of a draw at the same elevation as the magnesian limestone on the other side. There is evidence in this region, as elsewhere in the Ozark uplands, of mechanical deformation of the beds. Whether or not the displacement of the sandstone blocks can be attributed to the forces by which the Ozark uplift was formed, still remains in doubt.

The finding of misplaced strata and the observations which go to show that some of the third magnesian limestone beds are vesicular or filled with small drusy cavities, give evidence that the rock at some places may have possessed the conditions which are favorable for the concentration of lead and zinc ores.

The numerous springs which occur in this area and the abundance of water flowing in the Little Piney River, give evidence of circulating waters, which are a necessary agent in the deposition of ore bodies in rock such as occurs in this region. That the circulating waters of this region, at one time or another, have carried lead and zinc ores in solution, is shown by the fact that these ores actually occur as a replacement in the Third Magnesian limestone formation.

The problem which presents itself to the prospector is to find a locality where conditions have been favorable for the concentration of the ores into bodies of workable size.

* * * * * *

During the afternoon of the first day at Newburg an examination was made of such portions of sec. 36, T. 37, R. 9 W., as are mentioned in the above descriptions. In the S. W. ¼ of the N. W. ¼ of this section a drift has been run into the hillside following zinc ores, both the sulphide and carbonate, with the hope of encountering a workable deposit. The drift is about 200 feet long and is almost level. It was run in on very hard ground, consisting partially of chert or flint. In a number of places in the drift zinc sulphide and zinc carbonate occur, filling or lining small irregular cavities. These ores of zinc usually occur together. The carbonate forms a periphery around the blende and is undoubtedly an alteration product of it.

From such observations as it was possible to make, it appears that the zinc ore does not occur in any well defined sheet or vein. It appears, however, that the bed of magnesian limestone, in which the drift has been run, contains numerous cavities and irregular clay openings, in many of which ore has been deposited. The clay which occurs with the zinc, however, has in all probability been brought in and deposited subsequent to the original deposition of the zinc ore.

In one place, near where the drift branches, the flint rock is somewhat brecciated. At this place, both the carbonate and sulphide of zinc

were moderately plentiful. The mineral in the clay pockets is ordinarily galena and not zinc sulphide or blende.

At this place the base of the sandstone formation is about 160 feet above the level of the Little Piney, which flows at the foot of the hill in which the drift is located. The first galena found at this place during the early days was picked up about 15 feet below the contact between the sandstone and the limestone beds. About 50 or 60 feet below this contact another horizon was examined, in which irregular masses of carbonate and sulphide ores were observed, partly filling the irregular cavities of the rock.

In general, at this place, lead and zinc ores have been found at three different horizons in a thickness of about 160 feet of Third Magnesian limestone.

If I were to recommend anything in the way of development at this place, I would suggest that search be made for a possible broken or brecciated zone in the vicinity of the present drift. The only evidence of such a zone was the small width of brecciated chert found near the place where the tunnel branches.

* * * * * *

On the second day, the 19th of April, an examination was made of the S. E. 1/4 of the N. W. 1/4 of sec. 3, T. 36, R. 9 W., on which is located a prospect in which Mr. J. L. Buskett is interested. The barometer showed that the sandstone at this place was normally about 165 feet above the Little Piney River at Newburg. The top of the Buskett shaft was found to be about 135 feet above the river. Thirty feet above the mouth of the shaft is a contact between the limestone and sandstone and the latter continues to the top of the bluff about 90 feet above.

The Buskett shaft was sunk several years ago and is now filled with water. For this reason I was unable to examine the rocks beneath the surface. Mr. Buskett furnished me with the following section, showing the rocks passed through and the thickness of each from the top to the bottom of the shaft:

No. 1. 3½ feet soil and clay with lead in clay.

No. 2. 1½ feet hard mottled flint.

No. 3. 3½ feet hard gray brittle limestone and flint nodules. Veins running north and south with lead and zinc.

No. 4. 3 feet bluish-gray sandstone. Some lead and zinc. Veins continue.

No. 5. 3½ feet gray siliceous limestone containing nodules of flint. Veins continue carrying barite and sphalerite.

No. 6. 2½ feet black and blue flint, with nodules of gray limestone. Considerable zinc sulphide and barite.

No. 7. 4 feet limestone, similar to No. 3, and barite, but no lead or zinc. Lower part merges into white flint.

No. 8. About 14 feet very white brittle flint for about 5 feet, then 3 or 4 feet containing nodules or yellowish gray limestone. The lower 6 or 7 feet contains clay openings, carrying barite and some zinc and lead.

When the three feet of bluish gray sandstone was encountered, the water came in very strong and increased until at a depth of 35 feet, it was impossible to handle it except with a large pump. Quite a number of pieces of rock containing zinc in the form of the sulphide and carbonate were scattered about the shaft. These were examined and found to resemble closely the deposits occurring on sec. 36, T. 37, R. 9 W. Apparently most of the mineral occurs in irregular cavities in the rock, although a rather clearly defined vein probably occurs near the surface where this shaft was sunk. The beds in which ore was encountered are probably the same as those occurring in the previously described locality.

The next property examined was the S. E. ¼ of the S. W. ¼ of sec. 34, T. 37, R. 9 W., on which a drill hole had been sunk to a depth of nearly 100 feet. This place is about 95 feet bove the level of the Little Piney River at Newburg. At a depth of 98 feet, it is reported that an opening carrying mineral was struck.

On the N. W. ¼ of the N. E. ¼ of sec. 6, T. 36, R. 9 W., outcrops were examined in the vicinity of three shafts, from all of which zinc ores have been taken. The different shafts were all sunk near the bottom of a small but somewhat precipitous ravine—two on the west and one on the east slope. The first shaft was sunk to a depth of 57 feet. Eighteen feet from the surface a drift was run west 40 feet. This shaft passed through about 17 feet of loose bouldery clay at the surface, the remainder being in solid rock. Occasional large bunches of crystalized galena were found in cavities in the rock through which the drift was made. This ledge is about 60 feet below the bottom of the sandstone formation and corresponds in position with the upper zinc-bearing limestone bed observed on sec. 36, T. 37, R. 9 W., and with the lowest bed in Buskett's shaft.

The second shaft, on the west side of the draw, had a depth of 20 feet, of which 16 feet are in talus, 2 feet in flint, and 2 feet in a clay seam. Both zinc and lead, in the form of the sulphide, are reported as occurring in a seam below the talus. The seam is said to trend in a northwest southeast direction.

The shaft on the east side of the draw has a depth of 20 feet. About 12 feet from the surface, a drift was run west at the same level as the drift in No. 1. Some zinc blende, zinc carbonate, and galena occur in this drift, partially filling the irregular openings in the limestone. In

this drift the lead and zinc occur together. Iron pyrites is associated, to a considerable extent, with all the lead and zinc ores taken from these shafts. Several drill holes have been sunk in the immediate vicinity of the shafts, and although it is reported that galena was found, it does not appear that any workable ore body was encountered.

After examining the above described land, I inspected the S. W. ¼ of the S. E. ¼ of sec. 33, T. 37, R. 9 W., where several small holes had been dug into the hillside. At a horizon about 55 or 60 feet below the sandstone some lead and zinc have been found, but not in any larger quantity than on the previously described property.

Conclusions.

After considering carefully the conditions in this area and reflecting upon the developments which have been carried on, it is thought that one would be justified in saying that thus far the prospecting has not brought to light any very large body of ore. It appears that the strata which carry the lead and zinc ores, are open porous rocks, and the relation of the sandstone and limestone formations leads me to feel *that there may be in this region* places where open ground has been sufficiently extensive to account for the deposition of lead and zinc in workable quantities. If one could find a moderately wide zone of brecciation or a considerable thickness of open vesicular rock in which the lead and zinc ores could have been deposited, he would be thoroughly justified in continuing prospecting by drifting or sinking shafts.

It is believed, however, as a whole, that not enough attention has been given to a consideration of the conditions necessary for the occurrence of an ore body and that more money should be spent in work preliminary to the sinking of shafts and running of drifts than is being done at the present time. It would be to the advantage of any company or corporation to employ a competent economic or mining geologist, for two months, searching for the conditions which indicate favorable localities for prospecting before sinking shafts or running drifts. The expenditure of $300 or $400 in preliminary work would be money well expended.

If it is the intention to continue work on the shafts and drifts at any of the localities which were inspected, the showing made on sec. 36, T. 36, R. 9 W., is most favorable. In continuing work in this tunnel it would be wise to sink down on the brecciated or broken ground as closely as possible, with the hope that it may lead to more favorable conditions.

The fact that the shafts at the other localities examined were filled with water, making it impossible to thoroughly examine the properties,

impels me to refrain from making any comparisons. I believe that if it had been possible to have inspected the underground conditions at the three places, I would have found them to have differed very little.

I trust that in this report I have made myself clear, and should there be any questions or explanations necessary, I hope you will feel at liberty to call on me and I will make such explanations as I can. Respectfully submitted,

E. R. BUCKLEY,
State Geologist.

PETITION OF C. W. M. LOVE ET AL., KINGSTON, MO.

Petition to examine the following described lands, to wit: The principal part of the E, ½ S. E. ¼ sec. 19, 65 acres, and the south 61 acres of the W. ½ S. W. ¼ sec. 20, in T. 56, R. 27, owned by Algernon Wingate, E. ½ S. W. ¼ sec. 19, E ½ N. W. ¼ sec. 30, same township and range, owned by Hugh L. Baker and wife, N. ½ N. W. ¼ sec. 27, same township and ranges, owned by Joseph J. Boyd and wife, S. ½ N. W. ¼, N. E. ¼ and S. E. ¼, N. W. ¼ and S. E. ¼, N. E. ¼ and S. W. ¼ N. E. ¼, all in sec. 21, same township and range, owned by George J. Boyd, W. ½ S. E. ¼ and S. E. ¼ S. W. ¼ and 40 acres off of the south side S. ½ N. E. ¼ sec. 15, and N. W. ¼ N. E. ¼ sec. 22, same township and range, owned by W. H. Pearse and wife, S ½ S. W. ¼ and N. E. ¼ S. E. ¼ sec. 21, and S. ½ N. W. ¼ and N. ½ S. W. ¼ and N. ½ S. ½ S. W. ¼ and N. E. ¼ and S. W. ¼ of sec. 22, same township and range.

The above petition was answered and the following report submitted to the interested parties:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF KINGSTON.

In answer to your petition of October 28th, 1901, I spent April 15th and 16th in making an examination of the above described lands.

During the first day of this examination, I was accompanied by Mr. C. W. M. Love and Mr. Horace Johnston, and the second day by Mr. Horace Johnston. The purpose of this trip was to ascertain, if possible, whether the indications for petroleum and gas in this vicinity are sufficient to warrant deep drilling.

The rocks around Kingston belong to the Upper Carboniferous formation, many of the ridges exposing what is known as the Bethany limestone. Below the Bethany limestone, there is probably a thickness of about 400 feet of Upper Carboniferous rock, below which occurs Lower Carboniferous limestone.

There are certain conditions controlling the occurrence and distribution of oil and gas which must be looked for in an examination of prop-
imilarly located to that in the vicinity of Kingston.

First—One should determine, if possible, whether or not the conditions have been present for the production of oil or gas.

Second—Whether there is a reservoir for the storage of the oil or gas.

Third—Whether such reservoir is sealed by an overlying impervious strata of rocks through which the oil or gas cannot escape to the surface.

Any resemblance which there may be between the surface features of this region and that of the western Pennsylvania or Ohio oil and gas fields, is no justification for sinking a deep well with the expectation of finding oil. The escape of oil and gas from the rocks has some significance in a consideration of the probable occurrence of oil in any undeveloped territory, but it must be used in connection with other phenomena. In some cases it has a value in locating oil wells, but the assumption that the escape of gas and oil at the surface indicates the presence of great reservoirs underneath is often untrue and consequently misleading. It may be safely said that nine out of every ten surface indications of gas and oil represent no large accumulations beneath the surface.

The iridescent scum covering pools of stagnant water in marshes is often referred to as an indication of oil. This iridescent film is usually hydrous, iron oxide or bog iron ore. One must understand and recognize the fact that there are various kinds of surface indications, and that by far the larger portion of them do not indicate extensive reservoirs of either oil and gas.

During the two days which were spent in the vicinity of Kingston I found a bituminous limestone on the N. E. ¼ of the N. E. ¼ and also on the S. ½ of the N. W. ¼ of sec. 34, T. 57, R. 27 W. This limestone occurs along a small branch and shows the presence of a black tar-like substance, which is probably asphalt. Undoubtedly the same indications of oil may be found at other places in this region. The bitumen has its source in the series of rocks in which it occurs, and is not derived from a deep seated reservoir.

From my examination of this region no conditions or surface indications were observed which would warrant the presumption that either oil or gas, in large quantities, will be found by deep drilling. It is possible that within a depth of 400 or 500 feet a small quantity of heavy ptroleum or asphalt might be obtained, but there are no indications at the surface which would warrant the presumption that petroleum or gas occur below that depth. Deep drilling which has been done in north central and northwestern Missouri gives no encouragement to deep drilling for petrloeum or gas in this part of the state.

I cannot consistently recommend the expenditure of money in this region in deep drilling for petroleum or gas. Respectfully submitted,

E. R. BUCKLEY,
State Geologist.

PETITION OF S. P. COLLINS, SR., ET AL., JERICO, MO.

Petition to examine the following described lands, to-wit:

N. W. Cor. sec. 3 to S. W. Cor. sec. 2, S. W. direction across N. E. Cor. 10, into sec. 11, T. 33, R. 28 W.

S. W. Cor. sec. 1, T. 33, R. 28, N. E. into sec. 36, T. 34, R. 28, and sec. 31, T. 34, R. 27; secs. 15 and 16, T. 34, R. 27 W., E ½ of N. E. ¼ sec. 6, T. 33, R. 28; secs. 21 and 28, T. 34, R. 27.

S. E. ¼ of S. W. ¼ sec. 20, T. 33, R. 28.

N. W. ¼ of S. E. ¼ secs. 29 and 30, T. 34, R. 28; sec. 17, T. 33, R. 27.

The above petition was answered and the following report submitted to the interested parties:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF JERICO.

In answer to a petition of 50 freeholders, residing in the vicinity of Jerico, I examined, in company with Mr. S. P. Collins, such parts of the above described lands as were thought to contain mineral.

This examination showed the occurrence of a brown iron ore between sections 26 and 27, T. 34, R. 28 W. Some bituminous limestone on sec. 14, T. 33, R. 28 W.; on sec. 36, T. 34, R. 28 W.; and on the S. W. ¼ of the N. E. ¼ of sec. 3. T. 33, R. 28 W. Spadalerite or zinc blende was found in two different shafts which have been sunk on the S ½ of sec. 16, T. 34, R. 27 W.

A large part of the region examined is underlain with Lower Carboniferous limestone. The ridges and hills, however, are capped with Lower Coal Measure shale and sandstone with which are interbedded thin layers of coal. The Lower Carboniferous limestone has, in some places, been weathered to such a degree as to be represented at the present time by a very fossiliferous brown residual chert. These residual cherts were examined in a great many places, but I was unable to find that they contained any ore in commercial quantities.

Bituminous limestone, such as is common to the Lower Coal Measures, occurs wherever the shales and sandstones or the upper beds of the Lower Carboniferous limestone are exposed. They have no special significance as to the probable occurrence of gas or petroleum in this region.

The iron ore, which is a brown hematite, occurs near the base of the Lower Coal Measure rocks and is pyritiferous. This ore has apparently resulted from an alteration of pyrite or marcasite. The iron ore examined contains too high a percentage of sulphur to be valuable.

The shafts sunk on sec. 16, T. 34, R. 27 W., have a depth of 70 and 216 feet, respectively. From both of these shafts pyrite, calcite and zinc blende were obtained. In the 70-foot shaft the zinc ore is reported to occur in thin seams and drusy cavities in the limestone. In the deep shaft it is reported that a 4-foot bed of limestone was encountered, which carried zinc blende, disseminated throughout its entire thickness.

It is very certain that zinc blende has been found in these shafts, but the quantity which occurs in the rocks has not been demonstrated.

Sufficient prospecting with the drill has not been done to prove this territory. The only way by which one can demonstrate the occurrence of a workable deposit of zinc ore in this area, is to drill or sink shafts into the underlying limestone. It is possible that paying quantities of zinc ore may be encountered, but it will require capital to prove the region. Respectfully submitted,

E. R. BUCKLEY,
State Geologist.

PETITON OF M. E. FERGUSON ET AL., QUINCY, MO.

Petition to examine the following described lands, to-wit:

Secs. 18, 19, 20, 21, 28, 29, 30, 31, 32, 33 and 34, T. 38, R. 23 W., and sec. 3, T. 37, R. 23 W., all in Hickory county.

The above petition was answered and the following report submitted to the interested parties:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF QUINCY.

In a response to a petition, signed by yourself and others, for the examination of lands in the vicinity of Quincy, I visited that place March 21st and 22nd, and, in company with yourself and others, inspected the lands above described.

With the exception of the higher ridges and hills, the land in the vicinity of Quincy is underlain with Lower Carboniferous limestone. In a number of places on the higher ridges Lower Coal Measure sandstone was observed.

In places the limestone is bituminous, carrying small percentages of what may be asphalt. The richest deposits of bituminous limestone were found on the E. ½ of the N. E. ¼ sec. 30, T. 38, R. 23 W., at which place there is a seam apparently filled with asphalt. A pit has been dug on this vein, to a depth of about 8 feet. The vein is reported to be 18

inches thick, and to continue to an unknown depth. At the time that I made the inspection, a half barrel of asphalt stood near the pit, which, owing to the spring freshets, had caved in.

Bituminous limestone was also observde in the N. W. ¼ sec. 21, T. 30, R. W., and in the middle of the E. ½ of sec. 19, T. 38, R. 23 W.

On the S. W. ¼ S. E. ¼ sec. 24, T. 38, R. 23 W., a shaft has been sunk to a depth of about 48 feet, in search of zinc and lead ores. This shaft is on land owned by John Brown, who kindly furnished me with the following description of the rocks passed through.

10 to 12 feet talus.

6 feet shaley, sandy dolomite.

6 to 7 feet coarsely crystalline limestone, carrying some calcite.

6 feet dense coarse crystalline limestone, which has been brecciated and recemented with calcite.

20 inches blue shale, in which is disseminated considerable zinc blende.

10 to 11 feet limestone, chert and blue clay.

5 feet of uniformly fine grain limestone.

5 feet of rough, bouldery limestone, containing clay and pyrite.

The relations of the shale beds and limestone and the evidences of brecciation, combined with the occurrence of blende in the 20-inch layer of shale, leads me to consider this an excellent prospect. It is thought that the developments thus far carried on, give sufficient encouragement to warrant the expenditure of considerable money in continued explorations.

West of the shaft and in the bed of the creek there occurs considerable quantities of barite, disseminated through which are bunches of galena. This vein of barite seems to be of considerable width and moderately free from iron oxide. The occurrence of galena with the barite and the relation which the two bear to the country rock, makes this also a favorable point for prospecting. Without railroad facilities it may be impossible to sell the barite at a profit, but should railroad facilities be obtained, both the barite and lead, should they be found to occur in considerable quantities, will find a ready market.

With the exception of the asphalt occurring in the N. E. ¼ of sec. 30, T. 38, R. 23 W., and the lead and zinc in the localities above mentioned, no mineral prospects were found which would warrant the expenditure of any considerable money in development. Very respectfully submitted,

E. R. BUCKLEY,

State Geologist.

PETITION OF W. H. PAYNE ET AL., ALTON, MO.

Petition to examine the following described lands, to-wit:

S. W. ¼ sec. 9., S. W. ¼ sec. 3, S. W. ¼ sec. 17, S. W. ¼ sec. 18, W. ½ sec. 26, and W. ½ of sec. 28, all in T. 23, N., R. 2 W.

The above petition was answered and the following report submitted to the interested parties:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF ALTON.

The 18th of October, 1901, was devoted to an examination of mineral prospects in secs. 9, 17, 18, 28, 29, of T. 23 N., R. 2 W., 5th principal meridian.

The examination of these lands was made in company with Messrs. W. H. Payne and J. H. Harder. The first place examined was a ridge on which occurred boulders of ferruginous chert, mingled with ironstone. These iron-bearing cherts were observed 200 paces northeast on the same ridge and at other places in the vicinity. Near the base of the hill, on which they occur, but farther north, brown hematite was observed, mingled with chert and forming a brecciated mass. At this place a shallow hole had been dug, but no body of ore was revealed.

The next place visited was a shallow excavation in the limestone. Thin veins of what appeared to be calcite were observed cutting the rock, but there was no evidence of zinc or other mineral.

The next place visited was a shallow excavation in the side of a ravine. This opening showed a bed of white, yellow and purple clay, some of which had the appearance of chalk. This deposit is not considered evidence of the occurrence of either lead or zinc.

The sixth place visited was a shallow excavation, six or eight feet deep, showing brown hematite, mixed with chert. The surface of the ore is glazed in some places and frequently has an iridescent sheen. The quality of the hematite appears good, but the amount is apparently limited.

The seventh place visited was a small opening in a yellow limestone ledge near Mr. Harder's field. This limestone does not appear to contain any lead or zinc, but thin veins of calcite occur in many places.

The eighth place examined was an outcrop of limestone and chert at the head of a neighboring valley. The rock was apparently a cherty dolomite, containing layers or fragments of quartzitic rock. The stone is in places stained brown with iron oxide.

The ninth place examined was a shallow excavation, seven feet deep, showing a hard, flinty limestone, containing drusy cavities. An examination of samples from this place did not reveal any minerals of importance. Across the ravine from this place another excavation had been made in the limestone—an assay of which, by a man named Ogden, showed 80 cents per ton of gold.

A short distance east of this excavation was another from which a sample of limestone is said to have assayed $1.20 per ton.

Two shallow excavations have been made between secs. 29 and 30, but there was no mineral of value in sight.

The last place examined was on the east side of sec. 25, T. 23, R. 3. Here there was exposed a deposit of manganese of unknown quantity. Samples taken into the laboratory showed it to be very pure oxide of manganese.

Conclusion

The inspection of these lands revealed considerable quantities of a good grade of brown hematite (iron ore) and evidence of manganese in the form of the oxide. Nowhere has development progressed sufficiently far to warrant a statement concerning the quantity available.

The iron seems to be very much scattered in small patches throughout this area. Only one deposit of manganese was seen, but the fact that it occurs in this region would justify one in making a diligent search for a workable deposit.

The rocks ore of such a nature and the region is so situated that the presumption is against the occurrence of gold and silver in workable quantities. On the other hand, the situation of the land is such that one might expect to find zinc ores in the district. However, none were found at the places inspected, as shown by analyses made in the Bureau laboratory. Respectfully submitted,

E. R. BUCKLEY,
State Geologist.

PETITION OF JOHN B. KENNEDY ET AL., CAMERON, MO.

Petition to examine the following described lands, to-wit:

S. E. ¼ sec. 26, T. 58, R. 30 W., county of DeKalb.

The above petition was answered and the following report submitted to the interested parties:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF CAMERON.

The surface rock of the land in the area above described is limestone. The streams have cut channels through this limestone exposing

clay, clay shale, carbonaceous shale and a thin seam of coal. The coal seam is about 2½ inches thick and at one place dips about 12 degrees N. W. Underneath the coal is a thickness of 2½ feet of fire clay, which passes into shale, carrying many nodules of flint and limestone.

It appears from the examination made, that this coal seam is the marginal portion of what may be a larger deposit to the northwest. Whether a workable seam would be found at a shallow depth below the creek bottom can only be demonstrated by drilling or sinking a shaft forty to fifty feet. The presumption is somewhat against the possibility of striking a workable seam at this depth.

If coal is not met with at the depth above mentioned, I would not expect it to be encountered above a depth of 275 or 300 feet. The quantity of coal to be found at this depth is not known. One would need simply to speculate on the favorable indications.

Should you decide to sink a shaft or drill a hole to the depth of forty or more feet, I trust you will give me an opportunity to examine the material passed through. Very respectfully submitted,

E. R. BUCKLEY,
State Geologist.

PETITION OF J. C. CRANE ET AL., EXETER, MO.

Petition to examine the following described lands, to-wit:

Sections west of the city, in T. 23, Rs. 28 and 29 W., in the county of Barry.

The above petition was answered and the following report submitted to the interested parties:

GEOLOGICAL REPORT ON AN EXAMINATION OF LANDS IN THE VICINITY OF EXETER.

In compliance of a petition of 50 freeholders of Barry county, Mo., to inspect land in the vicinity of Exeter, especially the E. ½ of the S. E. ¼ of the S. W. ¼ of sec. 21, T. 23, R. 8, I examined said property, in company with J. O. Boucher, B. F. Northcut and J. C. Crane, on the 16th day of October, 1901.

My inspection included the examination of a shaft that had been sunk to a depth of 34 or 35 feet through clay and sandstone into about 10 feet of shale. The lower four feet of the shale bed was bituminous and contained thin seams of coal. The shale beds contain nodules of iron pyrites, known as sulphide of iron. At the bottom of the shaft there occurred a bed of sandstone, having a dark bituminous appearance, similar to certain beds encountered above the shale.

My inspection also included an examination of a small stream and

stagnant pools of water a short distance west of the shaft. The water in the stagnant pools was covered with a scum and contained a soft yellow mass of iron oxide.

The inspection further included an examination of water taken from a well about two miles northeast of where the shaft had been sunk. The water examined gave off no odor and there was no evidence of oil or gas.

The shale occurring in the shaft gives no evidence of gas or oil. The greasy appearance on the stagnant pools of water is due to the extraction of iron oxide from the water, and is no evidence of oil.

From the above I would conclude that there is very little reason for believing that oil or gas occurs below a depth of 300 feet on the property examined. Neither is it probable that oil or gas will be found in any considerable quantity within 300 feet of the surface.

The presumption is also against the probability of obtaining coal at a greater depth than 300 feet. Coal may be found inside of this depth, but whether or not it occurs in workable quantity can only be demonstrated by drilling or continuing the shaft to a greater depth. Respectfully submitted.

E. R. BUCKLEY,
State Geologist.

The petition of J. A. G. Reynolds and 50 freeholders of Ava, Missouri, was answered and reported upon by the acting State Geologist. This petition called for the examination of the following described lands, to-wit:

The S. W. ¼ of the N. E. ¼, and the S. E. ¼ of the N. W. ¼, sec. 13, T. 25, R. 16 W., in the county of Douglas.

A petition from G. C. Henson, Sr., and 50 freeholders of Holt, Missouri, for the examination of lands in the vicinity of that city was answered and reported on by the acting State Geologist prior to the present administration.

A petition of J. S. Carr and 50 freeholders of Center, Missouri, was found among the papers of the Bureau after the change of administration. This petition gives no description of the lands to be examined and was not legally certified to.

Besides the above petitions, a number of requests for the examination of mineral lands, which were not accompanied by petitions, have been answered and reported on. All of these requests have been answered in person by the State Geologist. Among the places visited for the purpose of making these examinations may be mentioned Fordland, Braymer, Creighton, Edgar Springs, Richmond, Joplin, St. Clair, Palmer, Aurora and Winston.

INTERIOR VIEW OF THE LIBRARY.

DISCUSSION OF THE MINERAL RESOURCES.

Asphalt and Asphalt Rock.

Thus far no workable deposit of asphalt has been found in Missouri. Thin seams or pockets in the Burlington limestone, filled with asphalt, are not uncommon, but nowhere does the so-called "tar" occur in sufficient quantity to warrant exploitation.

Asphaltic sandstone and limestone are both abundant through the west central part of the state. At one place, Liberal, the asphaltic sandstone is being quarried and sold for curbing and sidewalk purposes. In some places the stone appears to contain a sufficiently high percentage of bitumen to make it suitable for rock asphalt pavements, but in many places the percentage is much too low.

It is thought that these deposits, which are scattered over a considerable area in the western part of the state, give sufficient probability of value to warrant an examination by the Bureau.

Barite.

Barite, or barium sulphate, on account of its high specific gravity, is commonly known as heavy spar. In commercial quantities, it occurs mainly in the central and southeastern parts of Missouri, and is usually associated with the lead and zinc ores. The output for 1901, according to the report of the State Lead and Zinc Mine Inspector, was 32,388 tons, valued at about $3.22 a ton. The principal part of the output comes from Washington county.

The value of some of the zinc and lead mines is more or less impaired by the presence of barite, which constitutes the gangue mineral. An economical method of separating these minerals, when they occur together, would increase the output in the southeastern region. In the Franklin and Washington county mines, barite is the common gangue mineral, as far as the veins have, up to the present time, been exploited. The value of many of the mines in this county would be materially increased if it were known that the barite decreased with depth. As far as our examinations have gone, it is believed that this may be the condition in some instances, but in others the evidence of a generation of barite older than the zinc blende is evidence that it may continue with the zinc ore to the bottom of the vein. Further, there is evidence in this area of contemporaneous deposition of the barite and zinc blende. Before this question can be settled with any degree of certainty, a careful examination must be made of the deposits throughout the entire area.

Cement.

Cement is composed of a mixture of alumina, silica, and calcium carbonate in more or less definite proportions depending upon the kind of cement manufactured. Calcium carbonate is the most abundant constituent and, as used, occurs in the form of limestone or marl. Alumina and silica are usually supplied by clay or shale, of which they comprise the main constituents. These three necessary ingredients, calcium carbonate, alumina and silica, frequently occur in nature in approximately the correct proportions for cement, constituting a shaley limestone. Where such a combination occurs in a stone it is commonly known as hydraulic limestone, and from it natural cement may be manufactured.

Scientific investigations have shown that the best cement is obtained from a mixture of definite proportions of alumina, silica and calcium carbonate. The correct proportions of the constituents are obtained by mixing clay or shale with limestone or marl of known chemical composition. Cement which is made from such a combination is called Portland.

The following tables give the composition of a few of the typical limestones, marls, clays and shales used in the manufacture of Portland cement.:

ANALYSES OF TYPICAL LIMESTONES AND MARLS.*

	Chalk England (Reed).	Cement rock, LaSalle, Ill.	Cement rock, Siegfried, Pa.	Marl, Sandusky, Ohio.	Marl, Syracuse, Ind.
Calcium carbonate....	98.57	88.16	68.91	91.77	88.49
Magnesium carbonate	0.38	1.78	4.28	0.53	2.71
Calcium sulphate.....	....	....	....	3.19	1.58
Silica..................	0.64	8.20	17.32	0.22	1.78
Alumina..............	0.16	1.00	7.07	1.22	0.91
Iron oxide.............	0.03	0.30	2.04	0.40	0.30

*The Cement Industry, pages 12 and 13.

ANALYSES OF TYPICAL CLAYS.*

	Medway, Eng.	Harper, O.	Sandusky, O.	LaSalle, Ill.
Silica..................................	70.56	51.50	65.41	54.30
Alumina..............................	14.52	13.23	16.54	19.33
Iron Oxide............................	3.06	3.30	6.06	5.57
Lime..................................	4.43	11.52	2.22	3.29
Magnesia............................	....	3.45	1.88	2.57
Carbonic acid........................	3.48	12.85	....	....
Alkalies..............................	3.95	....	....	....

*The Cement Industry, pp. 12 and 13.

Missouri is supplied with unlimited deposits of clay, shale and limestone which together contain the three essential constituents for the manufacture of Portland cement. Two factories—the first in the state—have been erected in Missouri this year for the manufacture of Portland cement. One of the factories, located at Hannibal, and owned by the Atlas Cement Company, when completed, will have a capacity of 7,000 barrels a day. The other, located at Prospect Hill, just north of St. Louis, owned by the St. Louis Portland Cement Company, has a capacity of 1,500 barrels a day. This factory began operations about the first of November of this year.

The Hannibal, Hudson River and Hamilton formations, outcropping in many places throughout the eastern portion of the state, constitute an inexhaustible supply of shale suitable in many places to supply the necessary silica and alumina for the cement. The pure limestones of the Burlington, Lithographic and Trenton formations constitute an abundant supply of calcium carbonate for the remaining constituent.

It is thought that within a few years many more Portland cement factories will be erected in different parts of the state.

Clay Products.

There are over three hundred and fifty clay manufactories in Missouri, with a total output in 1901 of four and a half millions of dollars. The rapidly decreasing supply of lumber is compelling builders to look to brick, terra cotta and cement as the building material of the future. As the demand for constructional materials increases so will the search for suitable clays for the manufacture of these products increase. The growth of the clay industry in Missouri during the next decade will probably outstrip the development of any of the other mining resources, except, perhaps, the mining of lead and zinc and the manufacture of Portland cement.

The search for clay deposits suitable for the manufacture of the multitude of clay products now in use is constantly going on. Inquiries are constantly coming to this office asking for the location of clay deposits suitable for the manufacture of different kinds of clay wares. New deposits are being uncovered each month and samples are received for examination.

The richness and variety of the clays in Missouri are surpassed by few, if any, of the states in the Union. Their nearness to the coal mines, the extensive markets for clay wares at home and abroad and the excellent railroad facilities contribute to give this industry an advantage possessed by few of the neighboring states.

Coal.

The report of Mr. Charles Evans, State Coal Mine Inspector, for the year 1901 shows the largest coal production in the history of the state, amounting to 3,813,527 tons, valued at $4,716,331 at the mines. The number of mines and strip pits operated is reported to be 368. During the year new mines were opened by twenty-six different companies.

The work which the Bureau has been carrying on in Central Missouri has included an examination of several deposits of coal in Miller, Morgan and Moniteau counties. The coal in these pockets is worked by the strip pit method. These deposits afford a valuable supply of fuel for local consumption. However, the quantity of coal in any of the pockets examined is not sufficient to warrant the installation of modern machinery.

There are undoubtedly large bodies of coal in the northern and northwestern parts of the state which have not yet been discovered. It is thought that a careful study of the formations in these parts of the state might assist in extending the known extent of the coal fields.

Cobalt—See Nickle.

Copper.

As yet there are no producing copper mines in Missouri. From Dent, Crawford, Phelps, Shannon and other southeastern counties, reports have been received announcing the discovery of copper ores, but in no instance has exploration revealed a sufficient quantity of ore to insure profitable development. From one locality a car load of ore was shipped to a St. Louis furnace with very gratifying results. The only point in question is the quantity available. The ore is found mainly in the form of a carbonate or sulphide. The Bureau has made no examination of the deposits referred to and can give no idea of their probable extent.

Gas and Oil.

The Beaumont, Texas, oil excitement has naturally turned the attention of many people in Missouri to the possibility of finding these products in this state. A number of companies have been organized in the northern and western parts of the state for the purpose of prospecting for oil. As a result of these organizations a number of deep wells have been bored, few of which have given any evidence of oil or gas in commercial quantities. At Belton, near the Missouri-Kansas boundary, there are several wells which are producing a few barrels of oil a day. Outside of these, none of the wells are of commercial importance.

The oil excitement in Texas, Louisiana, Colorado, and elsewhere, combined with the fact that oil occurs, in small quantities, in some portions of the Carboniferous formation in Missouri, has interested many of our citizens to the extent of either writing to this office for general information on the occurrence of gas and petroleum or requesting the State Geologist to make an examination of lands in which they were interested. Individuals, oil companies, business men's clubs and city improvement organizations have all sought the service and advice of the State Geologist in prospecting for petroleum and gas.

Where it has been possible, I have visited the localities from which these requests came and have made such explanations and suggestions as the limitations of my office would permit. In other instances I have submitted written reports on the properties examined, giving all the evidence found in support of the opinion expressed.

A number of erroneous impressions prevail throughout the state as to the origin of petroleum and gas, which, if explained, might serve to direct the attention of the prospector into fields which give greater promise of returns.

One of the common beliefs is that there is a reservoir of petroleum under the Gulf of Mexico and that the wells at Beaumont draw their oil from this reservoir. This being the supposition, it is thought that a well need only be sunk to sea level in Missouri, in order to tap this great underlying reservoir of oil. Others believe that the so-called Trenton limestone is the great oil and gas bearing horizon of the continent, and that if this can be reached, unlimited supplies of oil and gas will be obtained. A seepage of oil from the rocks at the surface is evidence to others that petroleum occurs in considerable quantities deep within the earth. The occurrence of salt water and sulphur has also been pointed to as evidence of the occurrence of petroleum. It will be shown in the following pages that those who believe the above are often in error.

It is true that most of the petroleum and gas which is found in this country is brought from depths which are below sea level. At Tiffin, Ohio, gas is obtained at a depth of 1,500 feet, which is 747 feet below sea level; at St. Henry's, Ohio, gas occurs at a depth of 1,156 feet, which is 200 feet below sea level; at Muncie, Ind., gas occurs at a depth of 900 feet, which is just sea level. The Trenton limestone is a gas and oil reservoir in Ohio and Indiana. Seepage of oil in a certain part of the country has frequently lead to the discovery of oil in other parts. Salt water very frequently occurs with petroleum and gas, but they are not always the accompaniment of one another. Sulphur is also frequently associated with the deposit of petroleum, but this, in turn, is not always an evidence of the occurrence of oil. None of these in itself,

however, can be taken as conclusive evidence of the occurrence of petroleum or gas in commercial quantities.

A very common error, which is made in Missouri, is the mistaking of an iridescent scum which often floats on the surface of stagnant pools, as a seepage of petroleum. This scum, which occurs very commonly in swamps, is the accompaniment of flocculent deposits of bog iron ore. On several occasions during the last year I have been called to examine certain evidences of petroleum which turned out to be nothing more than the iridescent scum referred to above.

In many places throughout the western and northwestern parts of the state, there are numerous outcrops of bituminous shales, sandstones and limestones which have been considered by many people to be very strong evidence of the occurrence of petroleum at greater depths. Provided the conditions for concentration and storage are also present, these bituminous strata should be given consideration, but otherwise they have little significance.

There is an entire lack of knowledge on the part of the public, first, as to what phenomena may be considered evidence of the occurrence of petroleum, and, second, as to what the strategraphic and structural conditions in Missouri are which bear upon the question of petroleum and gas in this state. In the following pages will be found a resume of the manner of occurrence of oil and gas in the more important fields of the United States. From this resume it is hoped that the reader will be able to correct some of the current fallacies connected with the occurrence of petroleum and gas. Following this resume, a statement will be made as to the origin and methods of occurrence of oil and gas in different parts of the United States. I will also attempt to show how far the geologist can be of assistance to the gas and oil prospector.

Pennsylvania—The so-called Pennsylvania oil field comprises portions of Pennsylvania, New York, West Virginia and Ohio. It consists of sixty or seventy, more or less, isolated areas, commonly known as oil pools. The oil is contained in sandstone beds of Devonian and Carboniferous ages. These sandstone horizons occur at different depths from the surface, depending upon the portion of the mountainous regions in which they occur. There is a thickness of about 350 feet of strata containing three somewhat distinct horizons of sandstone. In some places only one of these horizons is present, while in other cases all three occur. Where all three are found, only the lowest is oil bearing. The two upper sometimes carry gas. The sand varies in texture from that which is very fine grained to that which is conglomeratic. The conglomeratic usually occurs at the lowest horizon.

Ohio-Indiana.—**The Ohio-Indiana gas and oil fields consists of three**

or four irregular areas in south-central Indiana and northeastern Ohio. The gas and oil occur in the limestone of the Trenton formation. The rock is oil and gas bearing only in limited areas, apparently depending upon the porosity of the rock. Where the oil and gas occur the rock is a porous, magnesian limestone. Outside of these areas the rock is non-magnesian and not porous. At Findley, Ohio, the gas bearing limestone was encountered at a depth of 1,100 feet.

Kentucky.—In Kentucky, as in Pennsylvania, the oil and gas strata occur in sub-Carboniferous and Devonian shales. Neither oil nor gas are found in the Trenton of this area. One of the horizons at which oil is found occurs 50 feet below the bottom of the Devonian, probably in the Clinton horizon. The other horizon is 150 feet above the upper surface of the Devonian.

Texas.—Texas has two important oil and gas fields, the Corsicana and the Beaumont. In the Corsicana field the oil is found in a highly silicious gray slate of Cretacious age. This horizon occurs at a depth of 1,050 feet. The oil of the Beaumont field is derived from sands which are probably of Pliocene age. The sands occur at a depth of from 900 to 1,000 feet. There appears to be no connection either in the age or the character of oil, between the Corsicana and Beaumont fields.

California.—In California the oil bearing rocks are mainly sandstone of Miocene or Pliocene age. Natural gas has been found in Cretaceous rocks in Caloosa county and in the Quarternary formations of San Joaquin county.

European Countries.—In the Galicia fields of Austria-Hungary, the oil bearing rocks range in age from Cretaceous to Miocene. The Roumanian oil is said to occur in rocks of the same age. The oil bearing rocks of the Baku fields in Russia are Lower Miocene.

Resume.—From this brief summary it will be noted that oil and gas occur alike in mountainous, hilly and prairie regions; that they occur in rocks of different ages, from Devonian to Quarternary time; and that they are contained in limestones and shales as well as sandstones. The kind and age of the rock do not seem to control the formation and storage of petroleum and gas in the formations younger than Cambrian. Other conditions besides these must be known before one can account for the present distribution of the oil and gas fields of the United States.

CONDITIONS AFFECTING AND CONTROLLING THE OCCURRENCE OF PETROLEUM AND GAS.

As far as the records show, petroleum and gas, in commercial quantities, have not been found in rocks older than Silurian. The Trenton limestone of the Indiana-Ohio fields constitute the oldest rocks in which

any commercial quantities of oil and gas are found. This occurrence is rather exceptional. Nearly all of the other petroleum or gas bearing strata are found in the Devonian or younger formations. This may be due to the fact that materials for the production of petroleum and gas were not present in the older formations or perhaps to the absence of conditions for the storage and retention of the oil and gas when once produced.

Origin of Petroleum.

It is generally conceded at present that both oil and gas are produced by the decomposition and distillation of organic matter laid down with the sediments which compose the rocks. It is thought that the oil and gas has in most cases resulted from the decomposition of organic matter, both vegetable and animal, deposited with the rock from which the gas and oil are now derived.

The oil and gas of the Pennsylvania field has undoubtedly been in a large measure derived from the shales associated with the sandstone strata. The gas and oil of the Indiana-Ohio field is thought to have resulted from the decomposition of the organic remains of which the limestone is largely composed.

Edward Orton, Sr., in his report on the occurrence of petroleum, natural gas and asphalt rock in western Kentucky, concludes, after a discussion of the various oil fields:

"1st, petroleum is derived from organic matter; 2d, petroleum of the Pennsylvania type is derived from organic matter of the bituminous shales and is probably of vegetable origin; 3d, petroleum of the Canada type is derived from limestones and is probably of animal origin: 4th, petroleum has been produced at normal rock temperature—(in American fields), and is not a production of destructive distillation of bituminous shales; 5th, the stock of petroleum in the rocks is already practically completed."

The Oil Rocks.

Any porous rock, which is overlain by an impervious strata and confined either by the limbs of an anticlinal fold or by changes in the texture and composition of the rock through which it becomes impervious on all sides, may constitute a reservoir for oil or gas. The porosity of sandstone and limestone and sometimes shales is sufficient to provide for the storage of all of the oil and gas which is produced from the interior of the earth. If a limestone or sandstone formation contains on an average of one-tenth of one per cent of petroleum and has a thickness of 500 feet, it will have a capacity of 2,500,000 barrels of petroleum to

the square mile. Edward Orton, in the report above referred to, estimated that a production from the oil field of Pennsylvania and New York of 300,000,000 barrels of oil would require only 125 square miles from the sub-Carboniferous limestone alone.

There is no difficulty in finding space in a rock sufficient to accommodate all of the oil and gas which can be distilled from the organic contents. Sandstone, which is the rock in which oil and gas are most commonly found, may be fine grained, coarse grained or even conglomeratic. The third oil sand of the Venango field is conglomeratic. It has been found that usually the coarse sands contain the largest quantities of oil, some of the conglomerates running as high as 10 per cent. These sandstones may be of uniform thickness over large areas, but frequently they occur as irregular lenses enclosed with shale or slate. Usually the sandstone horizons are of irregular thickness, varying from a few to several hundred feet.

Sandstones are usually more porous than either limestone or shale. Actual measurements have shown that ordinary sandstones contain from 10 to 29 per cent of pore space, providing an abundant reservoir for either oil or gas. Limestone constitutes the great reservoir for the oil and gas of the Ohio-Indiana field. This limestone is of Trenton age and in places is so porous, foot for foot, that it has been estimated to have a greater storage capacity than the sandstone of Pennsylvania. The Trenton limestone in this field is not everywhere porous. Apparently the solution cavities have been formed only where it is dolomitic. Where not dolomitic, the stone is compact and contains very little pore space for the retention or storage of either oil or gas. There are only limited areas of Trenton limestone in this field that are oil or gas bearing.

In western Kentucky the oil bearing rock is a shale. There are many places where small accumulations of oil are found in shales, but this is the only one where the oil is sufficiently concentrated to be of importance. The petroleum in these shales must be carried in the open joints and not in pores or cavities in the rock.

Nowhere is it necessary to suppose the occurrence of caverns or subterranean chambers to account for the storage of gas and oil within the earth.

The Impervious Cover.

After conditions for the production and storage of petroleum and gas have been fulfilled, provisions must be made for its retention. Oil and gas are both lighter than water and if an avenue of communication remains between the reservoir and the surface of the earth, the oil will cer-

tainly be brought to the top and there oxidized. So it has been found, that, wherever a reservoir occurs in which oil or gas are stored, this porous horizon is overlain with a fine grained, impervious shale or limestone which prevents the escape of the oil and gas. In any case this cap rock must be unbroken, else we need not look for oil or gas. Apparently in eastern and central Pennsylvania the breaking of the flexed strata has resulted in the dessication or evaporation of the petroleum.

Flexures.

The three conditions previously enumerated—a source for the petroleum and gas; a reservoir for its storage; a cap rock to prevent its escape above; may all be present in a given region, and yet no oil or gas be found. The reservoir must not only be capped with an impervious strata, but it must also be enclosed from east to west and from north to south, so that the oil and gas will be removed from the general circulation of underground water. A flexing of this strata, by which long canoe or dome shaped elevations are produced, provides the conditions desired for the retention of the oil and gas. Such flexures in western Pennsylvania and eastern Ohio constitute perfect reservoirs for the storage and retention of oil and gas. A modification of this so-called anticlinal structure is found in the terrace structure of the Indiana-Ohio field. Here the productive arch or anticlinal is low and flat, though similar in all respects to the sharper folds of the Pennsylvania fields. Edward Orton, in his report on the "Petroleum, Natural Gas and Asphalt Rock in Western Kentucky," explains the Terrace structure in the following words:

"In a region of uniform depth, for example, the upheaving force may go no further than to arrest the steady descent of the strata. If the whole had lain horizontal at the beginning, the force exerted would have been sufficient to bend them into a low arch; but, as the strata were descending, the force has all been used in arresting the descent and bringing the beds up to an approximately horizontal position for a small space. This peculiar structure has been designated arrested anticlinals."

The structure of the formation at Beaumont, at Corsicana and other fields, has not yet been worked out. W. B. Phillips, in a report of the Texas Mineral Survey on petroleum, states that there may be a flexure at Beaumont, the apex of which is at Spindletop.

In general we may recognize two classes of gas and oil fields: one, found upon the summits of low anticlinals, as illustrated in western Pennsylvania, and the other occupying the terraces such as occur in the Trenton limestone in northwestern Ohio and central Indiana. These

structures are vitally important for the retention of petroleum and gas in any region where the conditions are favorable to its production and storage.

In general, the man who prospects for oil must first know that the conditions for the production of petroleum have been present; second, that a reservoir in the shape of porous limestone, sandstone or shale occurs above the source of the petroleum or gas; third, that the reservoir is sealed above by an impervious formation of shale; and, fourth, that the strata have been so flexed as to form a dome or terrace in which the oil and gas are removed from the path of circulating waters.

Relation to Salt and Fresh Waters and Sulphur.

In many instances sulphur is found associated with the rock in which petroleum and gas is found. In the limestone capping the oil sand of Beaumont, native sulphur occurs. It has also been observed associated with the petroleum deposits in other parts of the country. In fact, the value of petroleum depends more or less upon the amount of the sulphur that it contains.

Salt is very often found with deposits of petroleum. The petroleum is lighter than salt water and naturally occurs on top of it. Fresh water is lighter than salt water and is frequently found between the petroleum and salt water. Where gas is found it precedes both the petroleum and water. The usual order in which these products occur is as follows: gas, petroleum, fresh water, salt water. It is known that in the Corsicana field below the oil horizon the sand is filled with salt water. The separation of the water, oil and gas is accomplished by gravitative forces. Edward Orton has very aptly said that "Where both oil and gas are found in a single field the first sign of approaching failure will be the invasion of the gas rock by oil or of the oil rock by salt water." Salt water follows the gas directly, however, in a great many fields without the intervention of an oil horizon.

Pressure.

The so-called "spouting" of oil wells, which gives them the name of "Gushers," is attributable to hydrostatic pressure. The flow of gas may be due in part to relief from compressed conditions in which the gas is confined in the reservoir. There is little plausibility, however, in the theory which attempts to account for this phenomena through the pressure exerted by the weight of the super-incumbent rocks. "The flow of gas and oil depends upon the pressure of a water column or in other words, every flowing gas or oil well is in reality an artesian well. With

the principle involved in an ordinary artesian well all persons are familiar and it will therefore be easy for such to extend the application of these wells to the cases now under consideration." (Orton.)

GEOLOGICAL AID TO OIL AND GAS PROSPECTORS.

The geological indications that can be made of service in locating oil or gas wells are: 1st, the succession of strata at any particular place, which includes such a knowledge of the rocks that one can state the probability of a reservoir occurring at proper depths; 2nd, the structure and arrangement of the beds from which one may determine favorable or unfavorable conditions for the retention of oil or gas.

A geologist should first ascertain whether conditions have been present for the formation of petroleum and gas; second, whether the successions of strata provide a suitable reservoir for storage; and, third, whether the structure of the beds are such as to provide suitable conditions for the retention of the oil and gas which may have been formed.

Seepages of oil and the presence of bituminous matter in shales, sandstones and limestones, are evidence that conditions existed somewhere for the production of petroleum. An examination of the rocks in which this bitumen occurs will probably furnish evidence as to the source of these products. A knowledge of whether conditions existed for the storage and retention of the oil and gas can only be obtained through a study of the geological conditions in all parts of the state in which the investigation is made.

In searching for domes, anticlinals and terraces, one must constantly bear in mind that each of these gradually die out with depth. A flexure of considerable amplitude, but of no great length or width, frequently dies out within a few hundred feet of the surface. After considering the depth to which an anticlinal or terrace continues, we must assure ourselves that the horizon included within this flexure is suitable for the storage of the petroleum and gas.

CONDITIONS IN MISSOURI.

The northern and western parts of Missouri are underlain at the surface with Upper and Lower Carboniferous rocks. The Lower Carboniferous rocks consist mainly of limestone, in which occur only occasional small pockets of bituminous matter in the form of asphalt. This heavy tar or asphalt originally had its home in the bituminous shales and sandstones in the form of petroleum. It now constitutes the residuum from the distillation of that petroleum which was oxidized by being brought into the zone of weathering. The tar residuum has slowly crept downward into the cracks of the limestone, where it is now found

filling crevices and pockets. Underneath the Carboniferous formation occurs a thick series of limestones and sandstones, none of which, as far as our observations go, present conditions favorable for the production of petroleum or for the retention of it should it have been formed in this horizon. The alternate series of dolomite and sandstone beds which are older than the Carboniferous rocks give no evidence of petroliferous deposits of any character.

The Upper Carboniferous rocks consisting of Coal Measure shales and sandstones outcrop throughout the northern and western portion of the state. The vegetable remains occurring in these beds are sufficient to account for the formation of petroleum and gas, while the sandstone horizons are sufficiently porous to provide a uitable reservoir for their storage. In some places in the northern and western parts of the state the rocks have been more or less flexed and towards the Kansas border in the west central part of the state, there is a probability of finding oil and gas in limited quantities. In some parts of the Upper Carboniferous formation, the bitumen occurs in the form of an asphalt. A considerable portion of the oils originally contained in the rocks have been brought to the surface through joints in the rock and here oxidized by the atmosphere. The lighter oils have been evaporated and the heavy residuum remains as a sticky mass in the pores of the rock.

The oil and asphalt which occur in this region has been derived from the Upper Carboniferous shales and are no evidence in themselves that larger deposits will be encountered below the Upper Carboniferous formations.

Gold and Silver.

As usual, a great many specimens have been assayed by the Bureau for gold and silver, but none were found to contain either of these metals in a measurable quantity. Some of the galena of the southeastern district is known to be argentiferous, but nowhere is either silver or gold known to occur in sufficient quantity to make profitable mining.

Iron.

Missouri is still a producer of iron ore, most of which is sold to furnaces within the state. The development of the enormously rich iron ore bodies of the Lake Superior region has in a large measure caused the Missouri iron banks to be abandoned. In some cases it was found that as the ore was mined to moderate depths, it was in part replaced by iron sulphide. Apparently the ore in some of the more important banks is an alteration product of iron sulphide. It is probable that with any increase in the demand for iron many of the old banks will be reopened.

The iron ore mined in 1901 came from Crawford, Dent, Franklin, Iron, Oregon, Phelps and St. Francois counties, and amounted in all to 140,280 tons.

Granite.

In the southwestern part of the state, in Iron and Madison counties, there are some of the most extensive deposits of red granite in the Mississippi Valley. The granite occurs in masses which constitute small hills and can be obtained in pieces of any desired dimensions. The stone is not only suitable for monuments and road materials, but it is unsurpassed for building constructions. It is hard, strong and durable, and takes a polish which is surpassed by very few red granites in brilliancy or luster. The granite when crushed makes an excellent product for macadam pavements or concrete walks. The curbing and paving blocks which are manufactured from the stone, although more costly to manufacture, are superior in strength and durability to the Georgia and similar gnessoid granites.

The output from the quarries in this district according to the United States statistical register for 1899, sold for $151,688, which is the maximum output since 1893.

Lead and Zinc.

The year 1901 showed an output of 109,376 tons of lead compared with 78,538 tons for 1900, an increase of 30,838 tons. The output sold for $4,865,518 in 1901, against $3,762,202 in 1900, an increase of $1,139,316. The average price of the lead ore was $44.30 per ton in 1901 against $47.47 in 1900.

The output of zinc for 1901 was 224,073 tons against 186,296 tons for 1900. Of this only 16,839 tons was silicate. The average selling price of the ore was $23.70 per ton in 1901 against $31.76 for 1900.* Nearly nine hundred mines were in operation in 1901 and the total output of lead and zinc amounted to $10,158,266.

The increased production for 1901 is due to a healthy and normal development of lead and zinc properties in different parts of the State. It can no longer be said that the southeastern and southwestern districts are the only lead and zinc producing sections. The south central and north central sections of the Ozark region south of the river, are both producing ore for the market. The production is unquestionably small when compared with the output of Jasper and St. Francois counties, but the districts are young and little is known as to their future possi-

*These figures are taken from the report of the State Lead and Zinc Mine Inspector, for 1901.

bilities. This year has witnessed the opening of two productive mines near Fortuna in Moniteau county, which has resulted in very general prospecting throughout the region. At West Plains, Howell county, a zinc oxide plant was erected this last year, the supply of zinc carbonate being drawn largely from Oregon and Howell counties.

The last year has witnessed the opening of several new mines in the southeastern district, but prospecting has been almost at a stand still. A number of new and old mines have been opened in the southwestern district, as a result of the advance in the price of zinc ore. Mining in both the southeast and southwest districts is on a scientific basis and prospecting is no longer carried on by "cut and try" methods.

The United States Geological Survey has three men in the Southwestern district engaged in a study of the ore deposits for the purpose of publishing a complete detailed report on the region. This work is receiving the hearty support and encouragement of the mining interests of that region. The importance of this work in the systematic development of the ore bodies and the opening up of new ones can only be appreciated by one who has been engaged in mining operations in this very complex region.

The mining interests of the southeastern, or disseminated lead region are expecting that the State Bureau will begin a similar line of investigation in that district during the coming season. The people of these districts contribute very largely to the wealth of the State and should receive any assistance which it is in the power of the Bureau to render. It is hoped that before another biennial period, the Bureau will have well under way a report on the Disseminated Lead district. Such a report will not only aid in developing the present mines, but should assist the prospector in extending the district into other undeveloped sectons.

Lime.

Although to some extent displaced by cement, quick lime is still produced in large quantities in Missouri. The limestone of the Upper Burlington formation is unsurpassed for the manufacture of white quick lime by any formation in the country. The Trenton limestone in the eastern part of the State is also a good lime producer. The dolomitic limestone of the Cambro-Silurian formations of the Ozark region has been used locally for the manufacture of quick lime, but nowhere has it been produced for shipping. The Burlington limestone makes a quick setting lime, while that produced from the Cambro-Silurian dolomites is slow setting. The former is usually very white, while the latter is gray.

The value of the output of quick lime in 1899 was $383,543, according to the statistical register of the United States Geological Survey.

Mineral Paints.

Not considering lead, zinc and barite, Missouri produces small quantities of the other common Mineral Paint, products among which are, Ocher, Umber, Sienna and Metallic paint pigments. The total output probably does not exceed six or eight hundred short tons per year valued at about $10,000.

Mineral Waters.

In 1901, thirteen mineral springs were reported to the U. S. Geological Survey as marketing mineral waters. During that year 784,-330 gallons were sold for $147,715. Missouri has not only some of the largest springs in the United States, but also hundreds of springs producing the most healthful drinking waters. Many of these are charged with magnesia, lithia, iron, sulphur, soda and potash, giving them unsurpassed medicinal qualities.

Nickel and Cobalt.

Nickel and cobalt occur, in small quantities, at Mine La Motte and the Catherine Mine in Madison county. The output during the last year sold for $5,964, exceeding that of all other parts of the United States. Nickel is used in certain alloys such as German silver; for plating iron; in storage batteries; in coinage; and to a small extent for medicinal purposes. Cobalt is valuable mainly for the intense blue color furnished by its protoxide. It is used in the arts especially for decorating porcelain and glass.

The nickel and cobalt ores in Madison county do not occur in sufficient quantity to pay for mining by themselves and the production is only incidental to the lead mining.

Oil—See Gas.

Petroleum—See Gas.

Pyrite.

Pyrite is valued entirely for the sulphur content which under normal conditions amounts to 53.4 per cent. Within the last few years there has been an increasing demand for iron pyrites in the manufacture of sulphuric acid and fertilizers. Pyrite occurs very widely disseminated through both the igneous and sedimentary rocks, but seldom is it concentrated sufficiently in one place to constitute a workable deposit.

The largest bodies in the state occur associated with the iron ores in some of the abandoned iron mines; as lenses and beds in the coal deposits; and as irregular lenticular masses associated with the lead of

INTERIOR VIEW OF THE MUSEUM.

Washington and neighboring counties. A good grade is worth from $4.00 to $5.00 per ton on board cars.

Sand.

Large quantities of sand are used each year for moulding, plastering, filtering, manufacturing glass, and many other purposes. It is estimated by the United States Geological Survey, that the annual consumption in the United States amounts to about 900,000 tons.

The sand used for foundry purposes in Missouri is largely obtained from alluvial deposits along the river. That used for filtering and glass manufacturing is largely obtained from the sandstone which occurs so abundantly at Pacific, Klondike, Silica and other places located on the so-called saccharoidal sandstone in the eastern part of the State.

Saccharoidal sandstone in many places is almost pure silicon dioxide. It is soft and friable and can usually be broken down with a pick and shovel. The unlimited supply of this sand in the neighborhood of Pacific accounts very largely for the location of the large Plate Glass works which are now being erected at Valley Park.

The importance of sand as a commercial product will sometime warrant the Bureau in publishing a special bulletin on the Silica deposits of Missouri.

Sandstone.

The sandstone quarried in 1901, according to the report of the United States Geological Survey, amounted to $42,170. The stone was used building constructions, paving, concrete, sidewalks, crosswalks, road making, grindstones and other miscellaneous purposes. There is perhaps no more desirable stone for sidewalks and crosswalks than a well indurated sandstone. It wears well and is not slippery. For building constructions much of the sandstone in Missouri is of excellent quality. It is thought that the sandstones of the Cambro-Ordovician formations should be used more extensively than at present.

Tripoli.

Tripoli, in Missouri, consists of very pure decomposed chert. It occurs in several places in the State, but the only consderable quantity is mined at Seneca in Newton county. The output of ground silica from the quarries at this place in 1901 amounted to 3,600,000 pounds, according to the State Mine Inspector's report. The product is nearly pure silica and is used for the manufacture of filters; in the form of powder as an abrasive; and in the manufacture of polishing paste and dynamite.

Three companies are operating at this place, two of which are engaged altogether in the manufacture of filters, blotters, etc. The third besides manufacturing filters, is engaged in grinding the silica for abrasive purposes. The capacity of the American Tripoli Company is 4,000,000 pounds of powder and 50,000 filters. The Seneca Filter Company works about six to eight hundred tons of the stone into filters at its plant and ships about an equal amount to East St. Louis where it is ground. The National Tripoline Company uses its output entirely for manufacturing filters. The waste is shipped as it comes from the quarry.

The deposits about Seneca are confined to a radius of about ten miles. They are in Lower Carboniferous rocks and vary in thickness from two to twenty feet.

Zinc (See under Lead).

LABORATORY.

The Bureau is very glad to receive specimens of any character—ores, minerals, stone or clay—and will examine carefully all such specimens and make a report to the individual sending them. Such examination will include a determination of the kind of mineral, rock or clay—but not a quantitative analysis or assay of the specimens.

However, the general work of the Bureau requires many analyses and assays in the preparation of special economic reports, and for the purpose of making these determinations, a well equipped laboratory should be provided. The Bureau should have a fully equipped chemical, physical and metallurgical laboratory—where it is possible not only to make chemical analyses of minerals and physical tests of structural materials, but where experiments in the concentration and reduction of zinc and lead ores may be constantly carried on. Any decrease in the cost of mining and milling these ores is equivalent to increasing the productiveness of the mines and if this can be brought about through the maintenance of a laboratory by the State there is entire justification in its establishment.

FIRE PROOF VAULT.

The building in which the Bureau is at present housed is not fire proof. There is constantly more or less danger of fire and should such a misfortune befall the Bureau, there would be no way of saving the records. So long as the Bureau is housed in a building without fire protection, there should be a fire proof vault provided in which to keep the note books, maps, manuscripts and records of the department. Provision must be made in some way to insure the safety of the Bureau property.

RECOMMENDATIONS.

The Bureau appreciates the inadvisability of attempting to prepare at once reports on all the resources reviewed in the foregoing pages. We recognize, however, the importance of placing this department on a basis which will meet the demands made upon it by the citizens of the State. We also appreciate the fact that a generous support of the State Bureau of Geology and Mines means proportionately more work in Missouri through co-operation with the United States Geological Survey. In topographic work alone, the United States Survey will cover every dollar appropriated by the State for this specific purpose. For every dollar this legislature appropriates for topographic work, the United States Survey will appropriate another. If $10,000 is appropriated to the Bureau for this work, there will be expended in Missouri through the plan of co-operation with the United States Geological Survey $20,000. As has been before stated some of the states have been entirely mapped under this arrangement. Ohio, is now appropriating $25,000 a year to carry out this plan of co-operation. The topographic maps have nothing to do with the geology of the region covered, but constitute a necessary basis for making a geological survey. Where a geologist is provided with a topographic map, on which to indicate the geology, he can work about twice as rapidly as where he is obliged to make his own map. It is of inestimable importance that a country should be mapped topographically before being surveyed geologically.

Recognizing this condition we feel that an item of $5,000 a year or $10,000 for the biennial period for topographic work should be one of the first considerations in the allotment of an appropriation to the Bureau for the next biennial period.

As stated above it is very important that work be continued as rapidly as possible in the preparation of geological reports on the fifty-two counties which, as yet, have not had even a reconnoissance report. For this purpose and for the administration of the Bureau, an appropriation of $10,000 a year or $20,000 for the biennial period is pre-eminently necessary.

The preparation of economic reports on the various mining industries—lead, zinc, barite, coal, clays, cements, etc., perhaps serve to promote interest in these industries more directly than any of the other publications of the Bureau. They not only serve as an aid to the miner in intelligent prospecting and mining, but also serve as the very best advertisement of the State's resources. An appropriation of less than $5,000

a year or $10,000 for the biennial period would do scant justice to this important work.

The Bureau has several other functions which should not be overlooked. The law directs the Bureau to bring together specimens in the form of a cabinet which will adequately represent the resources of the State. I interpret this as meaning that the Bureau should have among its collections not only fossils and rocks representing the stratigraphy of the State, but that it should bring together collections of minerals and ores which will interest and instruct, not only the scientific but also the industrial world. The Bureau should contain representative exhibits from all the producing mines of the State, and these exhibits should be accompanied by maps, charts and drawings illustrating the working of the mines.

The Bureau does not have such a collection today, although there are many valuable specimens in the cabinet. Such collections as are in the Bureau at present are not so classified or arranged as to be of the greatest value. Through the removal of the collections from Jefferson City to Rolla, they became somewhat badly disarranged. They have never been catalogued and many of the fossils have not been named.

The library of the Bureau is increasing in importance each year, and valuable additions are being constantly made in the shape of government reports and serial publications of American and foreign scientific societies. The volumes in the library have never been catalogued and it now takes an unnecessarily long time to find reports which are needed in the work of the Bureau. Both the specimens in the Museum and the books in the library should be catalogued and systematically arranged in the cases, in order to serve best the purposes for which they have been brought together. As previously mentioned the Bureau should devote some time to the preparation of type suites of minerals, ores, rocks and clays for distribution to the colleges and high schools of the State.

An assistant should be employed to catalog, classify and arrange the museum specimens and the books in the library and arrange suites of specimens for the colleges and prominent high schools of the State. However, the urgent needs of the Bureau are so many that provision for this item must be postponed until another biennial period.

We would therefore respectfully report that there is needed to carry out the most imperative work of the Bureau, during the next biennial period, a sum of not less than $40,000.

APPENDIX.

LIST OF PUBLICATIONS AND INDEX.

The following is a list of the publications of this Bureau up to the present time. The editions of all, with the exception of Volume I, on Coal Deposits; Volume XIII on Structural and Economic Geology; The New Year's Announcement; Biennial Report to the 41st General Assembly; Part II of Vol. XII; and the Biennial Report to the 39th General Assembly have been exhausted. They can only be obtained by purchase from second-hand book store.

GEOLOGICAL SURVEY, 1839-1840.*

(Henry King, State Geologist.)

1. *Report of a Geological Reconnoissance* of that part of the State of Missouri adjacent to the Osage river, made to William H. Morell, chief engineer of the State, by order of the Board of Internal Improvement, by Henry King, M. D., Geologist. (Senate Journal, Appendix, 1st Session, 11th General Assembly, pages 506-535.) Jefferson City, 1840.

GEOLOGICAL SURVEY, 1853-1861.

(George C. Swallow, State Geologist.)

2. *First and Second Annual Reports* of the Geological Survey of Missouri, by G. C. Swallow, State Geologist, 448 pages, 17 plates, 18 sections, 26 figures and 5 maps, 8vo., cloth. Jefferson City, December, 1855.
3. *Third Report of Progress,* of the Geological Survey of Missouri, by G. C. Swallow, 3 pages, Jefferson City, December, 1856.
4. *Fourth Report of Progress,* of the Geological Survey of Missouri, by G. C. Swallow, 8 pages. Jefferson City, December, 1858.
5. *Fifth Report of Progress,* of the Geological Survey of Missouri, by G. C. Swallow, 13 pages. Jefferson City, December, 1860.

* In this list the publications of the Survey are arranged in the order in which they were transmitted for publication.

GEOLOGICAL SURVEY, 1870-1871.

(Albert D. Hager, State Geologist.)

6. *Annual Report of the State Geologist*, of the State of Missouri, by Albert D. Hager, 23 pages. Jefferson City, December, 1870.

GEOLOGICAL SURVEY, 1871-1873.

(Raphael Pumpelly, State Geologist.)

7. *Report of the Geological Survey* of the State of Missouri, 1855-1871, by G. C. Broadhead, F. B. Meek and B. F. Shumard, 327 pages, 29 illustrations and 9 maps, 8vo, cloth. Jefferson City, March, 1873.
8. *Preliminary Report on the Iron Ores and Coal Fields*, from the field work of 1872, by R. Pumpelly, A. Schmidt, G. C. Broadhead and W. B. Potter, 671 pages, 190 illustrations and an atlas with 14 large sheets, 8vo, cloth. Jefferson City, April, 1873.

GEOLOGICAL SURVEY, 1873-1874.

(Garland C. Broadhead, State Geologist.)

9. *Report of the Geological Survey* of the State of Missouri, including field work of 1873-1874, by G. C. Broadhead, 794 pages, 91 illustrations and an atlas of 15 sheets, 8vo, cloth. Jefferson City, August, 1874.

GEOLOGICAL SURVEY, 1874-1876.

(Charles P. Williams, State Geologist.)

10. *Industrial Report on Lead, Zinc and Iron*, together with notes on Shannon county and its copper deposits, by Chas. P. Williams, Ph. D., Acting State Geologist, 199 pages and 11 illustrations, 8vo, cloth. Jefferson City, December, 1876.

GEOLOGICAL SURVEY, 1889-1894.

(Arthur Winslow, State Geologist.

11. *Bulletin No.* 1—By Arthur Winslow, G. E. Ladd, A. E. Woodward and G. Hambach, 85 pages and 2 sketch maps. Jefferson City, April, 1890.
12. *Bulletin No.* 2—A Bibliography of the Geology of Missouri, by F. A. Samson, 76 pages, 810 titles. Jefferson City, December, 1890.
13. *Bulletin No.* 3—By G. E. Ladd and A. E. Woodward, 101 pages, 4 plates, 3 sections and 2 sketch maps. Jefferson City, December, 1890.

14. *Biennial Report of the State Geologist,* transmitted to the 36th General Assembly, Arthur Winslow, State Geologist, 53 pages, 2 diagrams. Jefferson City, January, 1891.
15. *Bulletin No.* 4—A description of some Lower Carboniferous Crinoids from Missouri, by S. A. Miller, 40 pages and 5 plates. Jefferson City, February, 1891.
16. *Bulletin No.* 5—By Erasmus Haworth and G. E. Ladd, 86 pages, 5 plates and 5 figures. Jefferson City, July, 1891.
17. *A Preliminary Report on the Coal Deposits of Missouri,* by Arthur Winslow, 226 pages, 131 illustrations and 1 map, 8vo, cloth. Jefferson City, November, 1891.
18. Vol. II. *A Report on the Iron Ores of Missouri,* by F. L. Nason, 366 pages, 8 plates, 62 illustrations and 1 map, 8vo, cloth. Jefferson City, December, 1892.
19. Vol. III. *A Report on the Mineral Waters of Missouri,* by Paul Schweitzer, including notes of A. E. Woodward, 256 pages, 23 plates, 11 figures and 1 map, 8vo, cloth. Jefferson City, December, 1892.
20. *Biennial Report of the State Geologist,* transmitted to the 37th General Assembly, Arthur Winslow, State Geologist, 37 pages, 3 diagrams. Jefferson City, January, 1893.

GEOLOGICAL SURVEY, 1894-1897.

(Charles R. Keyes, State Geologist.)

21. Vol. IV. *Paleontology of Missouri (Part I),* by C. R. Keyes, 271 pages, 32 plates and 9 figures, 8vo, cloth. Jefferson City, June, 1894.
22. Vol. V. *Paleontology of Missouri (Part II),* by C. R. Keyes, 266 pages, 24 plates and 2 figures, 8vo, cloth. Jefferson City, June, 1894.
23. Vol. VI. *Lead and Zinc Deposits (Part I),* by Arthur Winslow, 387 pages, 12 plates and 71 figures, 8vo, cloth. Jefferson City, July, 1894.
24. Vol. VII. *Lead and Zinc Deposits (Part II),* by Arthur Winslow, 383 pages, 29 plates and 268 figures, 8vo, cloth. Jefferson City, July, 1894.
25. Vol. VIII. *Annual Report with Accompanying Papers,* by C. R. Keyes, 395 pages, 30 plates, 16 figures and 1 map, 8vo, cloth. Jefferson City, December, 1894.
26. *Biennial Report of the State Geologist,* transmitted to the 38th General Assembly, C. R. Keyes, State Geologist, 60 pages, Jefferson City, January, 1895.

27. Vol. IX. *Reports on Areal Geology (Sheets 1-4)*, by C. R. Keyes, A. Winslow, C. H. Gordon, Erasmus Haworth and F. L. Nason, 430 pages, 22 plates, 53 figures, 3 folio plates and 4 maps, 8vo, cloth. Jefferson City, April, 1896.
28. Vol. X. *Surface Features of Missouri and Bibliography* by C. R. Keyes, C. F. Marbut and J. E. Tood, 533 pages, 22 plates and 24 figures, 8vo, cloth. Jefferson City, June, 1896.
29. Vol. XI. *Clay Deposits,* by H. A. Wheeler, E. M., 622 pages, 39 plates, 15 figures and 2 maps, 8vo, cloth. Jefferson City, November, 1896.
30. *Biennial Report of the State Geologist,* transmitted to the 39th General Assembly, C. R. Keyes, State Geologist, 63 pages, 7 plates and 2 figures. Jefferson City, December, 1896.

GEOLOGICAL SURVEY, 1897-1901.

(John A. Gallaher, State Geologist).

31. Vol. XII. *Areal Geology (Sheets 5-10)*, E. M. Shepard, C. F. Marbut and G. C. Broadhead, edited by C. F. Marbut, 656 pages, 13 plates, 39 figures and 6 maps, 8vo, cloth. Jefferson City, December, 1898.
32. *Biennial Report of the State Geologist,* transmitted to the 40th General Assembly, by John A. Gallaher, State Geologist, 68 pages. Jefferson City, December, 1898.
33. *New Year Announcement of the Bureau of Geology and Mines,* by J. A. Gallaher, State Geologist, 27 pages. Jefferson City, January, 1900.
34. *Preliminary Report on the Structural and Economic Geology of Missouri,* by John A. Gallaher, State Geologist, 260 pages, 65 plates, 9 sections and 6 figures, 8vo, cloth. Jefferson City, September, 1900.
35. *Biennial Report of the State Geologist,* transmitted to the 41st General Assembly, by Leo Gallaher, Act. State Geologist, 55 pages. Jefferson City, January, 1901.

GEOLOGICAL SURVEY (SEPT., 1901, TO DATE.)

(Ernest R. Buckley, State Geologist.)

36. Biennial Report of the State Geologist, transmitted to the 42nd General Assembly, by E. R. Buckley, State Geologist, 83 pages, 8 plates. Jefferson City, January, 1903.

REPORTS IN PRESS OR READY FOR PUBLICATION.

Vol. I, 2nd Series—Geology of Miller county.

Vol. II, 2nd Series—Quarrying Industry.

REPORTS IN PREPARATION.

Vol. III, 2nd Series—Geology of Morgan and Moniteau counties.

COUNTY INDEX OF PUBLICATIONS.

The following is a brief index of the above listed reports of the Bureau of Geology and Mines as far as they pertain to the different counties in the State. The abbreviations used are as follows:

S. I & II—First and Second Annual Reports of the Geological Survey of Missouri, by G. C. Swallow.

P. I. 1855-71—Report of the Geological Survey of the State of Missouri, by G. C. Broadhead, F. B. Meek and B. F. Shumard.

P. I. 1872—Preliminary Report on the Iron ores and Coal Fields, by R. Pumpelly, A. Schmidt, G. C. Broadhead and W. B. Potter.

B. I. 1873-74—Report of the Geological Survey of the State of Missour, by G. C. Broadhead.

W. I. 1875-76—Industrial Report on Lead, Zinc and Iron, together with notes on Shannon county and its copper deposits, by Chas. P. Williams, Ph. D.

Bul. No. 1—Administrative Report; The Coal Beds of Lafayette county, by Arthur Winslow; The Building Stones and Clays of Iron, St. Francois and Madison counties, by G. E. Ladd; A Preliminary Catalog of the Fossils occurring in Missouri, by G. Hambach.

Bul. No. 2—A Bibliography of the Geology of Missouri, by F. A. Sampson.

Bul. No. 3—The Clay, Stone, Lime and Sand Industries of St. Louis City and county, by G. E. Ladd; The Mineral Waters of Henry, St. Clair, Johnson and Benton counties by A. E. Woodward.

Bul. No. 4—A description of some Lower Carboniferous Crinoids from Missouri, by S. A. Miller.

Bul. No. 5—The Age and Origin of the Crystalline Rocks of Missouri, by Erasmus Haworth; Notes on the Clays and Building Stones of Certain Western Central counties Tributary to Kansas City, by G. E. Ladd.

I—A Preliminary Report on the Coal Deposits of Missouri, by Arthur Winslow.

II—A Report on the Iron Ores of Missouri, by F. L. Nason.

III—A Report on the Mineral Waters of Missouri, by Paul Schweitzer.

IV—Paleontology of Missouri (Part I), by C. R. Keyes.

V—Paleontology of Missouri (Part II), by C. R. Keyes.
VI—Lead and Zinc Deposits (Part I), by Arthur Winslow.
VII—Lead and Zinc Deposits (Part II), by Arthur Winslow.
VIII—Annual Report with Accompanying Papers, by C. R. Keyes.
IX—Reports on Areal Geology (Sheets 1-4), by C. R. Keyes, A. Winslow, C. H. Gordon, Eramus Haworth and F. L. Nason.
X—Surface Features of Missouri and Bibliography, by C. R. Keyes, C. F. Marbut and J. E. Todd.
XI—Clay Deposits, by H. A. Wheeler, E. M.
XII—Areal Geology (Sheets 5-10), by E. M. Shepard, C. F. Marbut and G. C. Broadhead.
XIII—Preliminary Report on the Structural and Economic Geology of Missouri, by John A. Gallaher.

ADAIR.

B. I. 1873-74—pp. 222-226, 242, 244, 255. I—pp. 39, 59, 60, 62, 187. III—p. 214. X—pp. 177, 225. XI—pp. 307, 361, 507. XIII—p. 195.

ANDREW.

B. I. 1873-74—pp. 303-309, 311. P. I. 1872—pp. 36, 120, 121, 124, 134, 140, 145, 153. X—pp. 143, 227. XI—pp. 363, 507.

ATCHISON.

P. 1872—pp. 54, 154, 276, 317, 377, 378, 379, 380-385, 386. I—p. 101. X—pp. 142, 231. XI—pp. 364, 507.

AUDRAIN.

I—pp. 39, 80-82, 84, 187. X—pp. 169, 232. XI—pp. 270, 295, 307, 366, 508. XIII—pp. 195, 233.

BARRY.

W. I. 1875-76—p. 8. III—pp. 108, 109. VII—pp. 507, 508, 613, 622, 736, 737. X—pp. 106, 233. XI—pp. 308, 366, 508.

BARTON.

B. I. 1873-74—pp. 63, 97, 102-106, 115, 354. I—pp. 16, 46, 151, 161-165, 187. III—p. 215. X—p. 233. XI—pp. 308, 367, 508. XII Part III—p. 119.

BATES.

B. I. 1873-74—pp. 23, 125, 153, 155, 157, 159, 161, 163.—P. I. 1872—p. 39. Bulletin V—pp. 53, 56. I—pp. 20, 38, 43, 133, 139, 143-150, 157, 188. X—p. 233. XI—pp. 310, 368, 508. XII part II—pp. 33,34. Part III—p. 119.

BENTON.

B. I. 1873-74—pp. 106, 528. P. I. 1872—pp. 12, 134, 135. W. I. 1875-76—pp. 8, 57. Bulletin III—pp. 85-101. II—pp. 13, 80, 83, 174, 175, 232, 233. III—pp. 83, 84. VII—pp. 708, 719. X—p. 234. XI—pp. 349, 369. XII Part II—p. 108-190. XIII—pp. 135, 228, 240, 242.

BOLLINGER.

W. I. 1875-76—p. 9. II—pp. 233-237. VII—pp. 700, 735. X—p. 236. XI—pp. 173, 510.

BOONE.

I—pp. 39, 73-76, 79, 88, 167, 189. III—pp. 115, 116, 215, 216. X—pp. 153, 237. XI—221, 280, 310, 369, 509. XII Part III. XIII—p. 163.

BUCHANAN.

P. I. 1872—pp. 120, 122-124, 134, 140, 145, 153, 345, 346, 348, 349, 351-354, 356, 357. I—pp. 102, 103. Bulletin V—p. 137. X—pp. 144, 248. XI—pp. 370, 509, 545.

BUTLER.

P. I. 1872—p. 41. II—pp. 87, 163, 237, 240, 316. X—p. 250. XI—pp. 310, 510. XIII—p.95.

CALDWELL.

P. I. 1872—p. 98. I—pp. 39, 46, 99, 105-107, 190. X—pp. 145, 250. XI—pp. 278, 311, 370, 510. XIII—pp. 195, 208.

CALLAWAY.

P. 1872—pp. 36, 85, 86, 414. I—pp. 77-79, 167, 168, 190. II—pp. 13, 14, 75, 78, 82, 83, 182, 279, 280. III—p. 216. X—pp. 39, 157, 251. XI—pp. 42, 219, 273, 295, 311, 371. XIII—pp. 153, 234.

CAMDEN.

P. I. 1872—pp. 34, 43, 63, 67, 69, 147. W. I. 1875-76—p. 8. I—p. 167. II—pp. 94, 174, 175, 240-241. III—pp. 105, 140, 216. VII—509, 716-718, 725. X—p. 254. XI—pp. 194, 313, 371, 414. XII Part I—p 150. XIII—pp. 60, 95, 96, 100, 229, 243.

CAPE GIRARDEAU.

P. I. 1855-71—pp. 258, 276. VII—p. 700. X—p. 254. XI—pp. 166, 167, 313, 511. XIII—p. 137.

CARROLL.

B. I. 1873-74—p. 55. P. I. 1872—pp. 36, 43, 44, 62, 143, 147, 148, 150, 155. I—pp. 92, 107-109. III—p. 217. X—pp. 151, 272. XI—pp. 314, 371, 511, 545. XII Part II—pp. 252-312. XIII—pp. 193, 208.

CARTER.

II—pp. 21, 94, 95, 111, 241, 242. VII—p. 735. X—p. 273. XI—p. 180. XIII—pp. 78, 102, 234.

CASS.

P. I. 1872—pp. 9, 36, 98, 141, 142, 153, 166, 167, 169, 189, 195, 197, 204, 208, 209, 211, 212, 414. I—pp. 20, 132, 133. III—pp. 180-182, 217. X—p. 273. XI—pp. 314, 372, 510. XIII—p. 208. Bulletin V—pp. 56-57.

CEDAR.

B. I. 1873-74—pp. 24, 62-65, 67, 75, 244, 343, 344, 356, 377. I—p. 160. III—pp. 9, 153-157, 217-219, 255. X—p. 274. XI—pp. 373, 512. XIII—p. 248.

CHARITON.

B. I. 1873-74—pp. 285, 297. P. I. 1872—pp. 36, 71, 146. I—pp.91, 190. III—pp. 96, 219. IX—Bevier Sheet. X—pp. 152, 275. XI—pp. 316, 374, 512. XII Part II—pp. 312-369.

CHRISTIAN.

VII—pp. 509, 631-635, 739. X—p. 277. XIII—p. 165.

CLARK.

P. I. 1855-71—pp. 314-323. I—pp. 52, 167. X—pp. 173,278. XI—pp. 317, 513. XIII—pp. 162, 167.

CLAY.

P. I. 1872—pp. 96, 100, 103, 104, 134, 141, 153, 167, 317-320, 322-325. I—p. 85. III—pp. 98, 99, 140, 144, 161, 163-166, 202, 220-222. X—pp. 146, 280. XI—pp. 376, 512, 545. XIII—176, 197, 246, 247.

CLINTON.

P. I. 1872—pp. 11, 21, 143, 144, 149, 150, 155. I—pp. 21, 100, 103. III—pp. 109-111, 160, 222. X—pp. 145, 281. XI—pp. 376, 513. XIII—pp. 242, 247.

COLE.

B. I. 1873-74—pp. 322, 324-326, 328, 330, 334, 337, 338. W. I. 1875-76—pp. 17, 64. I—pp. 167, 168, 191. VII—pp. 510, 702-706, 736. X—pp. 156, 284. XI—pp. 317, 376, 513. XIII—pp. 127, 129.

COOPER.

P. I. 1872—pp. 158, 159, 162. B. I. 1873-74—pp. 526, 527. W. I. 1875-76—p. 8. I—pp. 127, 128, 167, 168, 170, 171, 191. S. I & II—pp. 186-202. III—p. 222. VII—pp. 510, 720. X—pp. 175, 285. XI—pp. 186, 317, 376, 513. XIII—p. 153.

CRAWFORD.

P. I. 1855-71—pp. 243-257. W. I. 1875-76—pp. 12, 136, 142. I—p. 167. II—pp. 86, 97, 99, 116, 118, 120, 122, 129, 132, 136, 155, 218, 220, 243, 311-313, 318, 319, 326, 418. VII—pp. 512, 684-686. X—p. 289. XI—pp. 193, 227, 377. XIII—p. 233.

DADE.

W. I. 1875-76—pp. 8, 16, 49, 50. I—pp. 160-162, 167, 191. II—p. 184. VII—pp. 512, 639-642. X—p. 292. XI—pp. 318, 378.

DALLAS.

W. I. 1875-76—p. 9. VII—pp. 513, 721, 731. X—p. 292. XI—p. 514. XIII—101, 117, 229.

DAVIESS.

P. I. 1872—pp. 98, 146, 151, 153, 154, 167, 203. B. I. 1873-74—pp. 312, 313, 314, 321. I—p. 99. III—pp. 175, 176, 223. X—pp. 180, 292. XI—378, 514.

DEKALB.

I—p. 100. X—pp. 144, 294. XI—p. 545.

DENT.

W. I. 1875-76—p. 140. I—p. 167. II—pp. 32, 86, 97, 116, 119, 123, 136, 149, 153, 154, 221-224, 312, 319-323, 327. X—p. 294. XI—pp. 319, 514. XIII—pp. 123, 125.

DOUGLAS.

P. I. 1855-71—pp. 188-202. W. I. 1875-76—p. 8. I—p. 167. II—pp. 224, 244, 245. X—p. 300.

DUNKLIN.

XI—p. 514.

FRANKLIN.

W. I. 1875-76—pp. 9, 12, 142.

P. 1872—pp. 68, 89, 90. S. I & II Lead pp. 16-28, 30. II—116, 118, 156, 174, 224, 245, 246, 275, 320. VI—p. 344. VII—pp. 514, 515, 693-699, 736. X— pp. 161, 318. XI—pp. 192, 224. XIII—pp. 121.

GASCONADE.

P. I. 1872—pp. 84, 85. II—p. 88. X—pp. 159, 268, 315, 319, 515. XI—pp. 235, 515.

GENTRY.

I—pp. 100. III—pp. 16, 167. X—pp. 143, 317. XI—p. 515.

GREENE.

S. 1 & 2 pp. 97, 99, 102, 104, 106, 118, 123, 204. VIII—pp. 263, 265, 270, 271.

W. 1875-76—p. 8. VII—pp. 395, 422, 430, 456, 481, 623, 624. VI—pp. 286, 297, 298, 301, 305, 340, 516, 627. X—p. 321. XI—pp. 320, 340, 379, 516. XII Part I. XIII—pp. 165, 178.

GRUNDY.

P. I. 1872—pp. 153, 156, 295. I—pp. 46, 96, 191. X—pp. 181, 322. XI—pp. 320, 380, 516. XIII—pp. 198, 208.

JEFFERSON.

P. I. 1855-71—pp. 304-322. W. I. 1875-76—pp. 9, 12. S. I & II pp. 30-34. II—pp. 100, 102, 112. III—pp. 71, 75-79, 115, 139, 198, 225. VII—pp. 522-524, 686-692, 677. X—p. 346. XI—pp. 189, 294, 392, 520. XIII—pp. 114, 133, 234, 237.

JOHNSON.

P. I. 1872—pp. 28, 29, 34, 35, 41, 43, 98, 144, 147, 149, 152, 154, 165, 166, 168, 169, 171, 172, 176, 180, 184, 186, 189, 190, 191, 194, 205-209, 211. Bulletin III—pp. 85-101. Bulletin V—pp. 72-75. I—pp. 20, 36, 128-132, 192. III—pp. 115, 150-152, 224. X—pp. 148, 346. XI—pp. 332, 393, 520. XII Part II—p. 34. XIII—pp. 185, 195, 242, 250, 251.

KNOX.

III—p. 226. X—pp. 173, 353. XI—pp. 334, 520. XIII—p. 167.

LACLEDE.

P. I. 1855-71—pp. 213-222. W. I. 1875-76—pp. 9, 12. III—pp. 141, 144, 226, 229. VII—pp. 722, 735. X—p. 354. XI—p. 520. XIII —p. 249.

LAFAYETTE.

P. I. 1872—pp. 35, 40-43, 46, 48, 50, 53, 55-58, 80, 82, 98, 143, 147, 155, 167-169, 192, 193, 197, 204. I—pp. 20, 35, 36, 43, 117-123, 173, 179-181, 192, 193. IX—pp. 10-97. X—p. 354. XI—pp. 334, 394, 521. XII Part II—p. 34. XII—Part III—pp. 96-247. XIII—p. 185.

LAWRENCE.

III—p. 226. VII—pp. 524, 613-622, 737. X—p. 357. XI—pp. 186, 336, 521. XIII—pp. 164, 178.

LEWIS.

I—pp. 137, 143. III—p. 227. X—pp. 173, 363. XI—p. 521. XIII —p. 167.

LINCOLN.

P. I. 1872—pp. 5, 35, 217, 221, 222, 235, 236, 238, 239, 240, 243, 244, 247, 248, 251, 253, 254, 255, 257, 258, 260, 263, 277, 280, 281, 285, 286, 287, 289. B. I. 1873-74—pp. 257, 261. I—pp. 166-168. II—pp. 72, 74, 82. III—p. 227. X—pp. 166, 364. XI—pp. 336, 522. XIII—p 143.

LINN.

B. I. 1873-74—pp. 222-226, 257, 260, 261. I—pp. 37, 43, 92-94, 167, 168, 193. X—pp. 180, 364. XI—pp. 436, 522. XIII—pp. 197, 198.

LIVINGSTON.

P. I. 1872—pp. 36, 141, 144, 155, 289, 290, 292, 293, 294, 295, 297, 299, 303, 311-313. I—pp. 95, 96, 108, 193. III—pp. 170, 228. X—pp. 180, 365. XI—pp. 396, 523. XIII—pp. 208, 250.

ST. CLAIR.

P. I. 1872—p. 86. B. I. 1873-74—p. 528. W. I. 1875-76—p. 8. Bulletin. III—pp. 85-101. I—pp. 156-159, 196, 197. II—pp. 75, 81, 83, 174, 260, 281. III—pp. 87, 89, 90, 235. VII—p. 721. X—p. 465. XI—pp. 239, 345, 416. XIII—pp. 161, 241.

ST. FRANCOIS.

W. I. 1875-76—p. 9. S. I & II—pp. 35-40. II—pp. 14, 16, 18-21, 23, 34, 42, 59, 305, 320-322. VII—pp. 531-533, 660-677. IX Iron Mountain Sheet, Mine Lamotte Sheet. X—pp. 87, 198, 466. XI—pp. 416, 531. XIII—pp. 68, 69, 73, 78, 89, 227.

STE. GENEVIEVE.

P. I. 1855-71—pp. 290-303. W. I. 1875-76—p. 9. II—pp. 99-101, 190. VII—pp. 534, 700, 735. IX—Mine La Motte Sheet. X. p. 473. XI—pp. 130, 194, 347, 416, 347, 531. XIII—pp. 60, 103, 179.

ST. LOUIS.

P. I. 1872—pp. 5, 16, 32, 35-37, 44, 253, 255-257, 259, 260, 287. B. I. 1873-74—p. 22. W. I. 1875-76—p. 9. Bulletin III—pp. 5-84. I—pp. 165, 166. III—pp. 79, 80, 235. X—pp. 65, 161, 467. XI—pp. 196, 288, 421, 441, 469, 532. XIII—pp. 130, 134, 136, 169, 236, 238.

SALINE.

P. I. 1855-71—pp. 157-188. P. I. 1872—pp. 36, 48, 144, 145, 148, 155. W. I. 1875-76—p. 8. I—pp. 123-126, 167, 171, 196. II—pp. 75, 80, 98. III—pp. 50, 54-56, 59, 62-69, 90-92, 111, 112, 234, 235. VII—pp. 531, 720-721. X—pp. 149, 475. XI—347, 422, 529. XIII—pp. 163, 193, 237, 238, 240.

SCHUYLER.

B. I. 1875-76—pp. 292, 294, 296-299, 301. I—pp. 39, 54, 57, 61, 196. X—pp. 176, 478.

SCOTLAND.

I—p. 53. X—pp. 176, 478. XI—p. 529.

SCOTT.

II—p. 217. XI—pp. 348, 423, 529.

SHANNON.

W. I. 1875-76—pp. 159, 163-167. II—pp. 16, 18, 20, 91, 94, 95, 116, 261, 263, 271. X—p. 479. XI—p. 138. XIII—pp. 95, 103, 125, 230, 232.

SHELBY.

P. I. 1855-71—pp. 65-73. I—pp. 86, 87, 197. X—p. 480. XI—pp. 284, 424, 530.

FINANCIAL STATEMENT SHOWING THE EXPENDITURE OF THE BUREAU OF GEOLOGY AND MINES

From January 1, 1901-January 1, 1903.

EXPENDITURES DURING 1901 UNDER THE ACTING STATE GEOLOGISTS.

Leo Gallaher—April 20, July 1—Salary	$953 81
Leo Gallaher—April 20, July 1—Traveling expenses	84 32
Leo Gallaher—July 1—Miscellaneous	1 50
A. C. McLaughlin—April 20, July 1—Salary	600 00
A. C. McLaughlin—April 20, July 1—Traveling expenses	46 00
D. K. Greger—April 22, May 23—Salary	473 33
D. K. Greger—May 23—Traveling expenses	10 35
James K. Hull—May 8—Salary	40 00
James K. Hull—May 8—Traveling expenses	103 95
E. M. Shepard—July 1, Sept. 1—Salary	450 00
E. M. Shepard—July 1, Sept. 1—Traveling expenses	124 08
G. W. B. Garrett—April 2, May 18—Expenses	110 45
O. A. Crandall—May 20—Expenses	9 95
John S. Logan—May 18—Expenses	17 30
H. H. Gregg—June 29, Aug. 21—Expenses	66 70
Robt. Wright—April 22, Aug. 6—Office expenses	129 50
Missouri, Kansas and Texas Railway	25
Etta L. Carter—April 20, July 1—Salary	300 00
Tribune Ptg. Co.—April 24, Aug. 29	5 00
Western Union Telegraph Co.—May 3, June 6—Telegrams	8 80
Pacific Express Co.—May 1, July 1—Express charges	15 37
American Express Co.—May 3, July 6—Express charges	8 60
H. A. Swift—April 22, July 5—Sundries	5 85
Scientific Publishing Co.—April 23	5 00
Missouri Pacific Ry.—April 27	19 57
Geo. E. Robinson—April 30	41 00
Dan Gundelfinger—May 9	1 10
Press Printing Co.—May 18	8 50
Jos. Goldman—June 15	10 00
Colliery Engineer Co.—June 15	6 00
Regis Chauvenet & Bro.—June 15	5 00
Wyckoff, Seamans & Benedict—Aug. 8	50 00
S. M. Greenridge—Aug. 8	5 00
A. M. Dockery—Aug. 14	9 50

EXPENDITURES FOR 1901 UNDER THE PRESENT ADMINISTRATION.

1901.

E. M. Shepard—Oct. 9, Dec. 9—Expenses	$148 25
H. H. Gregg— Dec. 3—Traveling expenses	37 50
Etta L. Carter—Nov. 16—Salary	50 00
Tribune Prtg. Co.—Oct. 5, Dec. 7—Printing and paper	178 20
H. A. Buehler—Nov. 7—Salary	60 00
J. S. Hammon—Nov. 7—Salary	13 50
E. R. Buckley—Sept. 12, Nov. 7—Salary	440 00
E. R. Buckley—Nov. 7—Traveling expenses	91 80
Office expenses—Sept. 12, Nov. 1—	126 96
J. S. Hammon—Dec. 5—Salary	18 45
H. A. Buehler—Dec. 6—Salary	40 00
E. R. Buckley—Dec. 6—Salary	250 00
E. R. Buckley—Dec. 6—Traveling expenses	31 70
Office expenses—Dec. 6	98 19
S. H. Ball—Dec. 24—Salary	64 71
S. H. Ball—Dec. 24—Traveling expenses	26 21
E. B. Craighead—Nov. 7—Traveling expenses	95 45
W. & L. E. Gurley—Nov. 26—Instruments	96 00
R. R. Dickerson—Sept. 21—Repairs to building	238 70

1902.

E. R. Buckley—Jan. 7, March 31—Salary	750 00
E. R. Buckley—Jan. 7, March 31—Traveling expenses	76 21
Office expenses—Jan. 7, March 31	115 92
S. H. Ball—Feb. 5, April 5—Salary	201 29
S. H. Ball—Feb. 5, April 5—Traveling expenses	155 18
H. A. Buehler—Jan. 7, March 31—Salary	120 00
H. A. Buehler—Jan. 7, March 31—Traveling expenses	36 10
A. F. Smith—Jan. 7, March 1—Salary	190 00
A. F. Smith—Jan. 7, March 1—Traveling expenses	156 46
Lena J. Strobach—Jan. 7, March 31—Salary	95 00
J. S. Hammon—Jan. 7, March 5—Salary	57 15
E. R. Buckley—April 2, June 3—Salary	750 00
E. R. Buckley—April 2, June 3—Traveling expenses	191 48
Office expenses—April 2, June 3	355 34
S. H. Ball—May 5, July 7—Salary	180 00
S. H. Ball—May 5, July 7—Traveling expenses	176 98
H. A. Buehler—April 2, June 3—Salary	120 00

H. A. Buehler—April 2, June 3—Traveling expenses....	151 33
A. F. Smith—April 11, June 3—Salary..................	180 00
A. F. Smith—April 11, June 10—Traveling expenses.....	173 13
Lena J. Strobach—April 11, June 3—Salary..............	75 00
J. S. Hammon—April 4 May —Salary..................	35 70
E. R. Buckley—July 7, Sept. 16—Salary..............	750 00
E R. Buckley—July 7, Sept. 16—Traveling expenses.....	146 11
Office expenses—July 7, Sept. 16.....................	562 29
S. H. Ball—Aug. 7, Oct 8—Salary.....................	180 00
S. H. Ball—Aug. 7, Oct. 8—Traveling expenses.........	39 16
H. A. Buehler—July 7, Sept. 16—Salary................	300 00
H. A. Buehler—July 7, Sept. 16—Traveling expenses....	133 91
A. F. Smith—July 2, Sept. 16—Salary..................	180 00
A. F. Smith—July 2, Sept. 16—Traveling expenses.......	107 14
C. F. Marbut—Aug 11—Salary........................	103 90
Lena J. Strobach—July 7, Sept. 16—Salary..............	75 00
F. B. Laney—June 3, Nov 7—Salary....................	153 33
F. B. Laney—June 3, Nov. 7—Traveling expenses......	246 29
Carl Smith—Aug. 7, Oct. 8—Traveling expenses........	112 40
E. M. Shepard—June 13, Aug. 18—Traveling expenses..	48 75
W. S. Allee—Jan. 7, Aug. 18—Traveling expenses......	46 15
C. F. Marbut—Sept. 16, Oct. 8—Salary................	110 00
C. F. Marbut—Sept. 16, Oct. 8—Traveling expenses....	135 36
T. J. Craig—Aug. 7, Sept. 16—Draughting..............	99 00
H. H. Gregg—May 12, Sept. 16—Traveling expenses....	34 70
E. R. Buckley—Oct. 8, Dec. 6—Salary................	750 00
E. R. Buckley—Oct. 8, Dec. 6—Traveling expenses......	69 47
Office expenses—Oct. 8, Dec. 6.......................	213 60
S. H. Ball—Oct. 8, Dec. 6—Salary....................	120 00
S. H. Ball—Oct. 8, Dec. 6—Traveling expenses........	131 73
H. A. Buehler—Oct. 8, Dec. 6—Salary................	180 00
H. A. Buehler—Oct. 8, Dec. 6—Traveling expenses......	84 65
A. F. Smith—Oct. 8, Dec. 6—Salary..................	180 00
A. F. Smith—Oct. 8, Dec. 6—Traveling expenses........	69 42
Lena J. Strobach—Oct. 8, Dec. 6—Salary..............	50 00
Tribune Printing Co.—Jan. 2, Oct. 17................	57 09
Graham Paper Co.—January, Oct. 15..................	27 00
G. A. Fisher—Dec. 6—Office expenses.................	2 10
Lawrence May—Oct. 8—Salary	10 50
R. W. McConnell—Sept. 16—Traveling expenses and salary	97 30
Catherine Luckett—Nov. 7—Salary	25 00

A. T. Sweet—Oct. 8—Traveling expenses	14 40
Otto Veatch—Oct. 8—Traveling expenses	19 90
Library Bureau—Feb. 17	248 80
E. B. Craighead—Sept. 11	52 45
E. R. Buckley—Dec. 6—Jan. 1—Salary	250 00
E. R. Buckley—Dec. 6, Jan. 1—Traveling expenses	9 45
Office expenses—Dec. 6, Jan. 1	33 50
S. H. Ball—Dec. 6, Jan. 1—Salary	46 00
H. A. Buehler—Dec. 6, Jan. 1—Salary	60 00
H. A. Buehler—Dec. 6, Jan. 1—Traveling expenses	18 60
A. F. Smith—Dec. 6, Jan. 1—Salary	60 00
Lena J. Strobach—Dec. 6, Jan. 1—Salary	25 00
Jesse Parker—Nov. 1, Jan. 1—Salary	35 25
E. M. Shepard—Nov. 1, Jan. 1—Traveling expenses	42 20
E. B. Craighead—Nov. 1, Jan. 1—Traveling expenses	34 70
Total	$16,755 30

MISSOURI BUREAU OF GEOLOGY AND MINES.

ERNEST ROBERTSON BUCKLEY, Ph. D., Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

TO THE

Forty-Third General Assembly.

JEFFERSON CITY, MO.:
TRIBUNE PRINTING COMPANY, STATE PRINTERS AND BINDERS

MISSOURI BUREAU OF GEOLOGY AND MINES.
ERNEST ROBERTSON BUCKLEY, Ph. D., Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

TO THE

Forty-Third General Assembly.

JEFFERSON CITY, MO.:
TRIBUNE PRINTING COMPANY, STATE PRINTERS AND BINDERS

MISSOURI BUREAU OF GEOLOGY AND MINES.
ERNEST ROBERTSON BUCKLEY, Ph. D., Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

TO THE

Forty-Third General Assembly.

JEFFERSON CITY, MO.:
TRIBUNE PRINTING COMPANY, STATE PRINTERS AND BINDERS

MISSOURI BUREAU OF GEOLOGY AND MINES.

ERNEST ROBERTSON BUCKLEY, Ph. D., Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

TO THE

Forty-Third General Assembly.

JEFFERSON CITY, MO.:
TRIBUNE PRINTING COMPANY, STATE PRINTERS AND BINDERS

BOARD OF MANAGERS.

His Excellency, Alexander M. Dockery, Governor of Missouri, Ex-officio President of the Board......................Jefferson City

Professor Edward M. Shepard, Sc. D., Vice-President.....Springfield

*President E. B. Craighead, A. M., LL. D., Secretary....Warrensburg

Hon. H. H. Gregg..Joplin

Hon. W. S. Allee, M. D....................................Olean

**Hon. Cecil M. Baskett.................................Mexico

*Resigned. Moved from the State.

**Appointed to fill the unexpired term of Dr. Craighead.

PREFATORY LETTER.

Bureau of Geology and Mines,
Rolla, Mo., Dec. 31, 1904.

To the President, Governor A. M. Dockery, and the Honorable Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to submit herewith a report on the work of the Bureau of Geology and Mines for the years 1903 and 1904, as required by law. The work of this department has reached all parts of the State and has dealt with every variety of mineral, clay and stone resource. The brief summary contained in the following pages, expresses very inadequately the extent of this work and its importance to the industrial development of the commonwealth.

On behalf of my associates and myself I desire in this place to express to you, the members of the Board of Managers, my appreciation of the interest you have taken in the work of the Bureau. As individuals and as a body you have contributed very largely to whatever success may have attended the work of this department.

The Bureau is completely and carefully organized and must in the future, as in the past, render valuable service to the people.

Your obedient sir,

E. R. BUCKLEY,

Director and State Geologist.

STAFF OF THE BUREAU OF GEOLOGY AND MINES.

Ernest Robertson Buckley, Ph. D........Director and State Geologist
Henry A. Buehler, B. S...................Assistant State Geologist
Arthur F. Smith, B. S.........................Assistant Geologist
Frank B. Van Horn, B. S.......................Assistant Geologist
Curtis F. Marbut, M. S........................Assistant Geologist
(Employed during the Summer field season.)
Miss Lena J. Strobach.....................Clerk and Stenographer

TABLE OF CONTENTS.

CHAPTER I.

THE AIMS AND OBJECTS OF THE BUREAU OF GEOLOGY AND MINES.

Most of the progressive states, in which mining is an important industry, have either a Geological Survey or a Bureau of Geology and Mines. Among these states might be mentioned Texas, Louisiana, Alabama, North Carolina, Georgia, Ohio, Indiana, Wisconsin, Michigan, Iowa, Minnesota, New York, Pennsylvania, Virginia, West Virginia, Maryland, New Jersey and Missouri.

The geological bureau or survey in each state constitutes a storehouse in which information relative to the mineral resources, (metallic and non-metallic), is collected; and from which anyone interested in the development of the mineral resources may obtain information. Information bearing on the mineral resources is collected and systematically filed for reference, to be given out again in response to inquiries. These geological bureaus also collect information systematically on the different mining resources,—one or two at a time,—and examine carefully all the mineral resources of counties,—one or more at a time, as the appropriation will permit,—in order to publish reports wherein these observations may be permanently recorded

The work which this Bureau is commissioned to do is clearly defined in the following chapters of the law creating the Missouri Bureau of Geology and Mines:

"Sec. 7503. It shall be the duty of the State Geologist and his assistants, under the instructions and directions of the board of managers, to carry on, with as much expedition and dispatch as may be consistent with minuteness and accuracy, a thorough geological and mineralogical survey of the State, already begun, with a view to determine the order, succession, arrangement, relative position, dip or inclination and comparative magnitude of the several strata or geological formations within the State, and to discover and examine all beds or deposits of mineral contents and fossils, and to determine the various position, formation and arrangement of the many different ores, clays, rocks, coals, mineral oils, natural gas, mineral and artesian waters and other mineral substances as may be useful or valuable; also, to note carefully the character of the soils and their capacities for agricultural purposes, the growth of timber

and other scientific matters that may be of practical importance and interest; and said geologists shall cause to be represented on the map of the State, by colors and other appropriate means, the various areas occupied by the different geological formations in the State, and to mark thereon the localities of the respective beds or deposits of the various mineral substances, and, on the completion of the survey, to complete a memoir of the geology and mineralogy of the State, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey. (R. S. 1889, § 5262.)

Sec. 7504. It shall be the duty of the State Geologist to make or cause to be made detailed maps and reports of counties or districts as fast as completed, which maps shall embrace all such geological, mineralogical and scientific details necessary to make complete reports of said districts or counties. The State Geologist may also, from time to time, publish or cause to be published any reports of work completed, in the form of pamphlets or bulletins for general distribution. (R. S. 1889, § 5263.)

Sec. 7505. It shall be the duty of the State Geologist to collect full suits of all materials, rocks, ores, fossils or other mineral substances of scientific or practical interest or utility as may be discovered, and that may be necessary to form a complete cabinet collection, to illustrate the various resources of the State, as may be necessary to assist in preparing the various reports of the survey. (R. S. 1889, § 5264.)

Sec. 7506. It shall be the duty of the said assistants to make full and complete examinations, assays and analyses of all such rocks, ores, soils or other substances as may be submitted to them by the State Geologist for the purpose, and to furnish him with a detailed and complete account of the results so obtained. (R. S. 1889, § 5265.)

Sec. 7507. The State Geologist, from time to time, may furnish items of general information or new discoveries for publication in newspapers: Provided, the preparation of the manuscript and publication thereof does not interfere with the progress or add to the expense of the survey; he may also have authority to furnish cabinets for colleges or public museums, located within the State of Missouri, of minerals, rocks, or fossils: Provided, said institutions shall pay the expense of preparing, labeling, transporting and putting up said collection, and also, further, that in the selection of said specimens the general State collection is not deprived of duplicates of the same, and that the State collection is not seriously injured. (R. S. 1889, § 5266.)

Sec. 7503b. On the presentation of a petition to the State Geologist signed by not less than fifty freeholders who reside in the neighborhood of lands situated in any county in this State which they may believe to

contain valuable or have found valuable ores, clays, rocks, coals, mineral oils or mineral matter, said petition being certified by the clerk of the county court in which the petitioners reside to contain the names of fifty freeholders residing within the neighborhood of the lands, which lands shall be described in the petition according to government surveys, it shall be the duty of the State Geologist in person or by assistants as soon as practicable to examine and inspect said lands and make report and map as to existence on said lands of valuable ores, clays, coals, mineral oils or mineral matter found, and embody the same in his report now directed to be made by section 7563, Revised Statutes of Missouri, 1899.

Briefly the work of this Bureau is as follows:

1st. To ascertain the relations existing between the different rock formations at or near the surface of the earth and prepare county reports containing maps, drawings and other illustrations setting forth these facts and giving the thickness, surface distribution, structure and characteristics of each formation.

2nd. To examine the metallic and non-metallic mineral resources, including stone, clay, cement, road materials, soils, water, lead, zinc, iron, coal, petroleum, asphalt, copper, barite, sand, etc., publishing complete reports outlining their distribution and describing their manner of occurrence.

3rd. To collect, name and arrange a collection of specimens illustrating the geology and mineral resources of the State; also to assist the colleges and schools in the making of similar collections.

4th. To examine ores, rocks, soils, clays, and other mineral specimens for citizens of the State, reporting as to the kind and value of any specimen submitted for examination.

5th. To disseminate, everywhere, correct ideas as to the occurrence, origin, and relation of ores, minerals and rocks, for the purpose of increasing the general intelligence of the public on matters pertaining to geology and mining.

6th. To answer all inquiries relative to the mineral resources of the State.

7th. To examine, upon petition of fifty freeholders, lands upon which ores, clays, stone or other mineral resources of value may be thought to exist.

8th. To co-operate with the United States Geological Survey and other bureaus of the United States Government where benefit will accrue to the State.

The ultimate purpose of this work is to aid in the development of the mineral resources (metallic and non-metallic),—1st, by preparing

maps, charts and reports which will assist the prospector in carrying on his work with greater accuracy and a higher degree of intelligence; 2nd, by calling the attention of the public to undeveloped and partly developed resources; 3rd, by examining and reporting on specimens submitted by citizens of the State to this department; 4th, by increasing the general intelligence of the public through the sending out to colleges and public schools mineralogical and geological collections and published reports and addressing mining clubs and other organizations; 5th, by answering inquiries relating to the mineral resources of the State.

The work of a bureau of this character, when properly conducted, pays for itself, in dollars and cents, many fold. This return to the State comes about through the assistance, in the form of advice, given individuals, relative to mining and prospecting. Intelligent advice may result (1) in the development of an important mining or quarrying industry, or (2) in preventing the expenditure of money in localities where the chance of discovering minerals or ores of value is very slight. In the first instance, the result is an increase in the taxable property, while in the second case the result is a saving of taxable property. You cannot tax a man for a hole in the ground, even though it may have cost fifty thousand dollars. On the other hand, if the same sum were expended in developments on land where ores of value are to be found, the land may increase in taxable value ten or perhaps a hundred fold. It is difficult to estimate the extent to which the Bureau of Geology and Mines is responsible for increasing and saving the taxable property of the State, but if it were possible to measure the results in dollars and cents, our people would have no hesitancy in giving this departmnet the most generous support.

On the other hand, if the State were to maintain this Bureau simply to conduct investigations for the purpose of increasing our scientific knowledge of the geology and mineralogy of the State, they would be doing nothing more, proportionately, than is being done by other states, by the United States and by foreign countries.

Complaint is frequently made that geological reports are too technical to be useful to the public and are consequently of little value. Those who write these reports are not altogether responsible for this condition. It must be recognized that this is not so much a defect in the published reports as in the individual, who evidently expects to read geological literature, understandingly, without first familiarizing himself with the elements of that science. The same person, however, would not attempt to read a volume on "Plant Morphology" without first acquainting himself with the elements of botany. If men do not have the time and inclination to first acquire the elementary principles of

geology they ought not condemn the reports for containing words and phrases which they, themselves, do not understand.

Probably the Bureau of Geology and Mines should provide a series of reports dealing with the elementary principles of Geology and Mineralogy. I believe that such a set of reports, taking the place with the public that the primer does in the public school, would very greatly enhance the value of the more or less technical reports of this department. Such a set of reports, in which the illustrations were mainly drawn from Missouri, could be used to advantage in the public schools, increasing very greatly the student's knowledge of the physical geography and mineral resources of the State.

In writing the reports of this Bureau special care has been taken to use language and terms which may be understood by the public, and thus, not only remove cause for criticism, but increase the value and usefulness of the publications. In one of the volumes, in which it was necessary to use a considerable number of uncommon words, a glossary has been inserted in which these terms are defined. As to how well we have succeeded in writing semi-technical reports in language that all may understand, we must leave the public to judge.

CHAPTER II.

EMPLOYEES, EQUIPMENT AND PUBLICATIONS.

This is practically the only bureau of the State government which is devoted to investigations requiring a technical training. It is practically the only department which demands of its employees that they have a technical knowledge of the subjects with which it is concerned. Yet it is understood that simply a technical training in geology and mineralogy does not fit one for the work of this department. The employees must be able to use their scientific training and knowledge in reaching conclusions, and then, finally, they must have the ability to so express themselves that the public may understand.

The Bureau is not intended to be a training school for students and the employees should be men of experience, who have received an education which fits them to carry on geological investigations, without other assistance than may come from careful supervision and direction.

The assistants in this Bureau, during the entire administration, have been chosen solely with regard to their ability. No other consideration has entered to influence the Board of Managers in their selections. The success, which has been attained, is in a large measure due to the Board having adhered strictly to this rule. One of the chief reasons for the efficiency of the U. S. Geological Survey has been that the selection of the men employed thereon has been in no way influenced by political considerations.

Since 1891, the work of this Bureau has been constantly interrupted by changes of administration. At the end of each four year period a new staff has been appointed. This has occasioned a great loss to the people of the State through the non-publication of unfinished reports. It requires several years for one to familiarize himself with the various geological problems in a State of this size, and, whenever there is a change in the directorship of the Bureau, the State loses thereby. In order to minimize the loss, provided there should be a change in administration, there has been inaugurated, during the last three years, a card catalog system of keeping and classifying the records. This system makes a great part of the data which have been collected during the last three years available to anyone who may succeed to this office. This system was fully outlined in the last biennial report and will not be dis-

cussed here. It suffices to say that these records have been kept up, as close as practical, and are now in good shape.

Library. A library, which is well stocked with reference books, public reports and current periodicals, is very necessary for the work of this Bureau. A geological library is as indispensible to the geologist as a law library is to a lawyer. Recognizing this fact, an attempt has been made to accumulate all the geological literature possible through exchanging the publications of the department for those of other similar organizations. As a result of such exchanges we now have between four and five thousand books and phamplets dealing with geological and mining subjects. There have been no funds available for the purchase of needed books, for which reason the library lacks many volumes which would be of great assistance in the investigations now being carried on.

The books and phamplets in the library have been arranged systemmatically in the cases and cataloged according to a card index system, especially adapted to our needs.

During the last biennial period about 300 books and pamphlets have been received in exchange for the publications of the Bureau. There are now, about four thousand volumes in the library. Many of the volumes, chiefly those from foreign countries, are unbound. It is difficult to preserve a book without binding and as soon as an adequate appropriation can be secured these volumes should be bound.

Museum. The law creating the Bureau charges it with the collection, arrangement and naming of specimens illustrating the geology and economic resources of the state, and to assist the colleges and schools of the State to make similar cabinet collections. During the last biennial period about five hundred specimens have been added to the collections making in all about 6,000 specimens now in the Museum. The specimens lately collected represent chiefly the lead and zinc ores of the state. As the different counties are surveyed, specimens, representing the geology and mineral resources of these counties as individuals, are collected. It is expected eventually to arrange these county collections, each by itself, and to add to them from time to time, as opportunity may permit.

Publications. The work of this Bureau is represented, in part, by the publication of reports. These are of three kinds; 1st—Biennial reports; 2nd—County reports; 3rd—Economic reports. The biennial reports are intended chiefly to provide the legislature and the public with a summary of the work of the department and a retrospect of

the mining developments during each biennial period. They do not contain the results of the investigations carried on by the Bureau, insomuch as it has been deemed wise to separate the administrative reports from those of a more technical and scientific nature.

During the last two years, two volumes of special reports have been published, one on "The Geology of Miller County" and another on "The Quarrying Industry." Two additional volumes are completed, one of which would have been published had there been sufficient appropriation. These reports are on "The Geology of Moniteau County" and "The Geology of Morgan County." Three other reports are in preparation, one on "The Geology of St. Francois County;" another on "The Geology of Newton County;" and a third on "The Lime and Cement Industries."

The county reports are based on a most careful investigation of every section of land, as well as all accessible mines, prospects, quarries and clay-banks in the county. They are accompanied by maps, showing the distribution of the economic resources and the various geological formations; cross sections, showing the structure and relations of the rock formations; and reproductions of photographs of mining and geological formations in the county. These are complete reports, thereby differing from the reconnaissance reports of Swallow, Broadhead and the other early geologists.

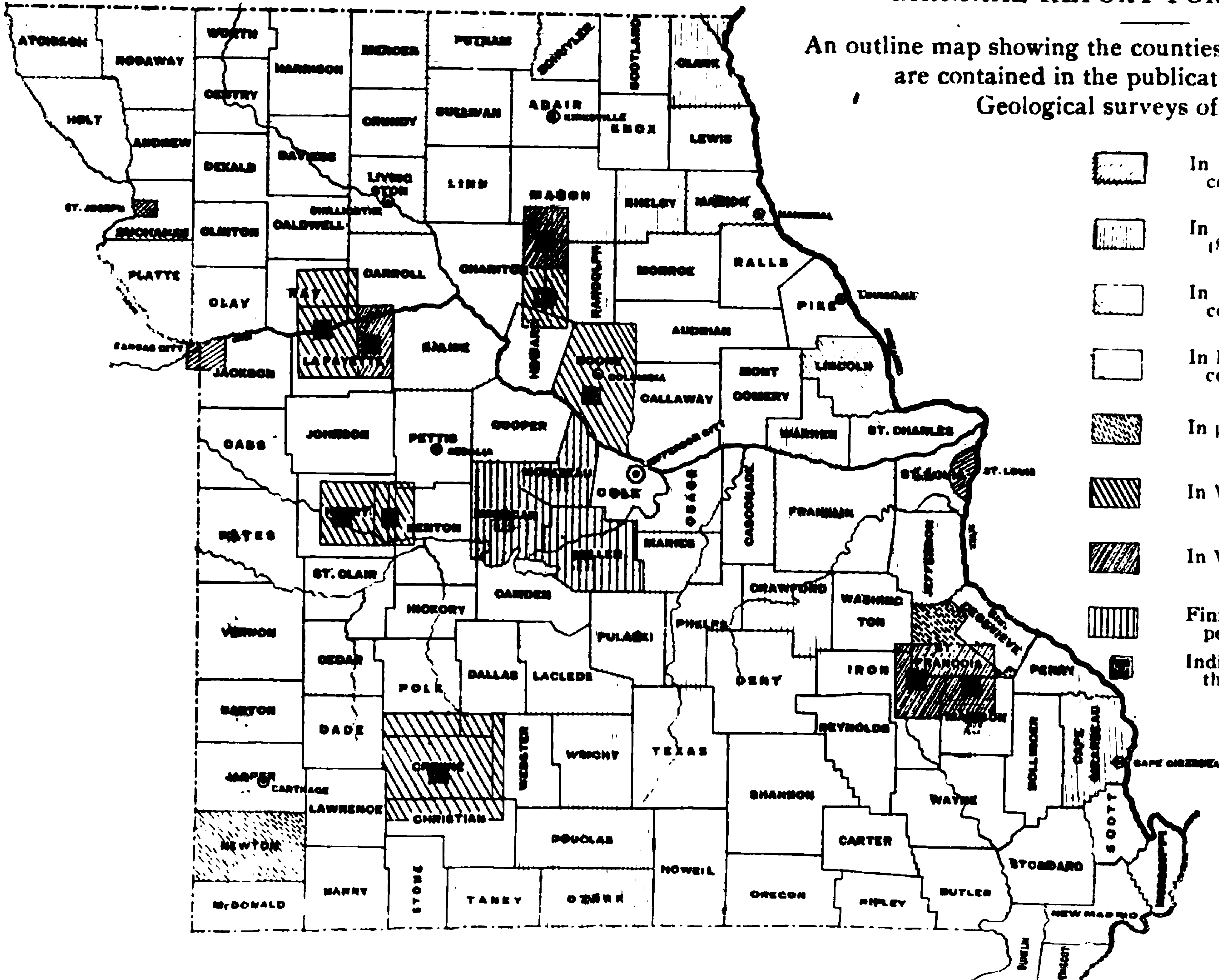
The nature of these reports can be understood better, by an exmination of the volumes than through their description. The following outline of the report on Moniteau County, which is in press, will give one an idea of what is embodied in these reports.

THE GEOLOGY OF MONITEAU COUNTY.

MISSOURI BUREAU OF GEOLOGY AND MINES.

BIENNIAL REPORT FOR 1903-04, PL. II.

An outline map showing the counties of which special reports are contained in the publications of the earlier Geological surveys of the State.



In Swallow's Report of 1855, 5 counties.

In Broadhead's et al. Reports of 1871, 21 counties.

In Pumpelly's Report of 1872, 8 counties.

In Broadhead's Report of 1873, 15 counties.

In preparation.

In Vol. XII.

In Vol. IX.

Finished during last biennial period.

Indicates that maps are printed of the respective counties.

Chapter III. Stratigraphy.
- A. Cambro-Ordovician.
  - (1) St. Elizabeth Formation, (2nd sandstone and part of 3rd Magnesian Limestone of Swallow).
  - (2) Jefferson City Limestone, (2nd Magnesian Limestone of Swallow).
  - (3) St. Peter's, (Pacific sandstone or 1st Sandstone of Swallow).
- B. Devonian.
  - Onondaga limestone.
- C. Carboniferous.
  - (1) Mississippian, (Lower Carboniferous).
    - (a) Chouteau limestone.
    - (b) Burlington limestone.
  - (2) Pennsylvanian (Upper Carboniferous).
    - (a) Graydon sandstone.
    - (b) Saline Creek cave-conglomerate.
    - (c) Shale and Coal.
- D. Pleistocene.
  - Glacial boulders.
- E. Recent.
  - (1) Soil.
  - (2) River Alluvium.
  - (3) Travertine.
- F. General section.

Chapter IV. Geological Structure.
- A. Folding.
- B. Faulting.
- C. Jointing.
- D. Unconformities.

Chapter V. Economic Considerations.
- (A.) Barite. (B.) Building stone. (C.) Cement. (D.) Clay. (E.) Coal. (F.) Iron. (C.) Lime. (H.) Lead and Zinc. (I.) Road Materials. (J.) Sand. (K.) Soils. (L.) Water Supply.

The areas which have been mapped and for which reports have been published up to date are shown on the accompanying map. The counties covered with red lines are those for which reconnaissance reports have been published. The counties covered with black lines are those for which detailed reports have been published or are in preparation. Those for which maps, either reconnaissance or detailed, have been published are indicated by red squares in the center of the county.

One economic report has been published during the last biennial period and a second is in preparation. The published report deals with the quarrying industry and especially with the building and ornamental stones. Very little reference is made in this volume to the manufacture of quicklime and cement, it being the intention to discuss these in a second volume which is now being prepared.

The character of these reports can be best judged by an examination of the volume which has already been published, an outline of which will be found in the last biennial report. The report on "The Lime and Cement Industries" is expected to cover the field represented by the following outline:

LIME AND CEMENT INDUSTRIES OF MISSOURI.

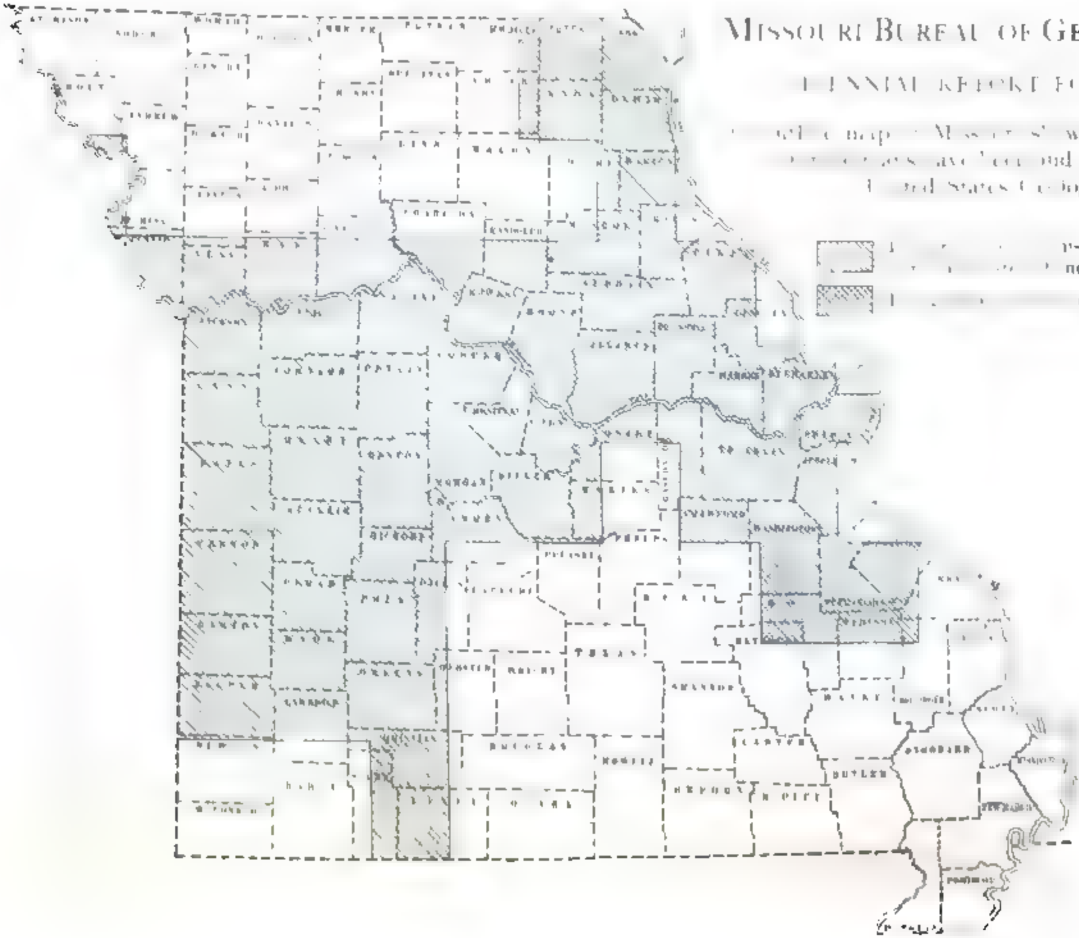
In addition to the maps and reports prepared by this department there has been prepared through a co-operative arrangement with the U. S. Geological Survey six topographic maps covering the areas indicated on the accompanying map. Besides this, work on another area has been begun as indicated on the map. These maps may be obtained from the U. S. Geological Survey or this Bureau for five cents a copy.

On December 1, 1904, the following volumes of the reports of this Bureau remained for distribution:

Preliminary Report on Coal Deposits, by Arthur Winslow	55
Preliminary Report on Structural and Economic Geology, Vol. XIII., 1900, by John A. Gallaher	3,095
New Year's Announcement, Jan. 1, 1901, by John A. Gallaher	433
Biennial Report of the State Geologist to the 41st General Assembly, by Leo Gallaher	463
Areal Geology, Vol. XII., Part II., by C. F. Marbut and G. C. Broadhead	195
Biennial Report of the State Geologist to the 39th General Assembly, by Charles R. Keyes	178
Geology of Miller County, Vol. I., 2nd Series, 1903, E. R. Buckley, A. F. Smith and S. H. Ball	2,125
The Quarrying Industry of Missouri, Vol. II., 2nd Series, 1904, by E. R. Buckley and H. A. Buehler	3,159
Biennial Report of the State Geologist to the 42nd General Assembly by E. R. Buckley	560

MISSOURI BUREAU OF GEOLOGY AND MINES.

BIENNIAL REPORT FOR 1903-04 PL. III.



Outline map of Missouri showing areas for which Topographic maps have been and are being made by the United States Geological Survey.

...shed. Over about two thirds of this ...nd inaccurate, must be re-surveyed

...preparation or planned for

These reports are distributed upon application, provided the request is accompanied with stamps to cover postage, as follows:

Vols. I and XIII, 25c each; Vol. XII, Pt. 2, 25c.; Vol. I, 2nd Series, 25c.; Vol. II, 2nd Series, 40c.; all others 10c.

The biennial report transmitted to the 42nd General Assembly contains a list of the publications of this Bureau and an index giving the volumes in which the geology of the different counties is discussed or referred to.

Miscellaneous Work. The publications represent only a small part of the work of the Bureau. There is a constant accumulation of data bearing on geology and mining in the State which are used for the purpose of answering intelligently the numerous inquiries which are received relative to the State's mineral resources. Scarcely a day passes that we are not called upon to examine specimens for some citizen who has little or no knowledge of geology. Through the mail we receive many inquiries concerning the mineral resources of different sections of the State. We answer correspondence which extends from Canada to Mexico and from the Pacific to the Atlantic. It has been our intention to answer to the best of our ability every inquiry no matter how unimportant or trivial it might seem.

In this connection we have been called upon to examine and report upon various localities in the State where the citizens have petitioned for the examination of mineral lands in accordance with law. The reports made in this connection will be found in the following chapter.

CHAPTER III.

REPORTS SUBMITTED IN ANSWER TO PETITIONS.

In 1901 the legislature passed a law directing the State Geologist to examine and report upon lands in any county in this State upon presentation of a petition signed by not less than fifty freeholders residing in the neighborhood of said lands, which they may believe to contain valuable or upon which they have found valuable, "ore, clays, rocks, coals, minerals, oils or mineral matter," said petition to be certified to by the clerk of the County Court in which the petitioners reside.

Since the passage of this law no specific appropriation has been made to carry out its provisions. Occasional petitions have been made and each has been answered in person either by the State Geologist or his assistant, the expenses being met out of the general appropriation for the Bureau.

The law does not require that the results of the examinations be published in the biennial report but rather in the final reports. It is believed, however, that the interests of the citizens are better conserved by publishing the results of these investigations in the biennial reports.

The following are copies of the reports made, during the last two years, in answer to petitions.

REPORT ON THE LENOX AND PARRY IRON COMPANY'S MINES.

Located in the S. W. 1/4 of the N. E. 1/4 of Sec. 32, T. 37, R. 6W.

These mines were examined on the 20th of January, 1903, in company with Mr. Lenox, Mr. Parry and others. The purpose of this inspection was to furnish an opinion as to the average quality of the ore and to make an estimate of the approximate amount of ore in sight.

The ore consists of soft, red hematite, limonite and blue specular hematite. In places the red hematite is soft and breaks down into a reddish brown powder. As a rule, however, the ore remains in pieces large enough for the furnace. The specular hematite is hard and in places appears to be siliceous.

All of the ore must be blasted before it can be removed from the mine, which, in itself, is evidence of the firmness of the ore. From an examination of the ore piles at the surface, and without making chemical analyses, one can say that the ore from this mine is a very good quality.

The fine dust-like product which constitutes a small part of the ore, ought to be suitable for the manufacture of mineral paint.

It was estimated that the three ore piles contained from 1,500 to 1,700 tons of ore ready to be shipped to the furnace. In the larger drift, it was estimated that there was from 5,000 to 7,000 tons of ore blocked out. In the second drift, it was estimated that there was in the neighborhood of 2,000 tons of ore in sight. It is thought that a conservative estimate of the ore in sight would place the amount at about 10,500 tons.

The ore is hauled from one of the drifts by a cable drawing a car up an incline. From the other drift the ore is hoisted through a shaft by horse power. It is dumped in piles, afterwards loaded into wagons and hauled about 5½ miles to what is known as the Winkler Spur of the St. Louis and San Francisco Railroad. When cars cannot be obtained, the ore is dumped onto a platform and from there later loaded into cars. The method of handling the ore is expensive and if possible a more economical arrangement should be provided.

It is thought that improved railroad facilities might increase very materially the output of this bank as well as induce the opening up of other iron ore deposits in the immediate vicinity.

Respectfully submitted,

E. R. BUCKLEY.

REPORT ON THE REGION CONTIGUOUS TO DIAMOND GROVE AND NEOSHO.

An examination of lands in the neighborhood of Diamond Grove, Neosho and Granby emphasizes very strongly the probability that the Joplin-Carthage-Webb City district will find its continuation in this direction.

The occurrence of extensive areas of Mississippian limestone and chert overlain with areas of Pennsylvanian shale, as in the Joplin district, offers the first evidence to substantiate the proposition that ore bodies will be found in this region. The limited and unsystematic prospecting already carried on, usually not deeper than 100 feet, has demonstrated that the underground waters of this region have been richly charged with zinc and lead, in solution. Conditions favorable to ore deposition are shown by the occurrence of rich deposits of galena and "silicate" near the surface

It appears now to be mainly a question of finding those areas where there was an abundnt circulation of the mineral bearing solutions through openings in the strata and under conditions which occasioned precipitation. There is little doubt but that such areas will be found,

as they have been in the now developed Joplin district. It will require, however, systematic prospecting to a depth of at least two hundred or two hundred and fifty feet to prove the land. The people of Neosho and Diamond Grove should be especially active in bringing the right men into the district that prospecting may be systematically and intelligently carried on.

At the time of my visit special attention was called to the old "Conner Diggings" and I was very much gratified with the results of the investigation. The prospecting at this place has uncovered several feet of residual flint and clay carrying ten to fifteen per cent (estimated) of galena. At another place, about a quarter of a mile south, surface explorations have resulted in uncovering several tons of silicate ore. These occurrences of ore show the former presence of mineralized solutions which may have formed extensive deposits of zinc blende, where conditions were favorable, perhaps at greater depths.

A generous, organized effort on the part of the people living and owning property in this region, to bring to the knowledge of prospectors the favorable conditions which exist in the Diamond Grove-Neosho region should result in extensive search for bodies of lead and zinc ores.

Very respectfully yours,

E. R. BUCKLEY.

REPORT ON PETITION FROM LACOMA.

Mr. A. C. Aldrich et al., Lacoma, Mo.:

Gentlemen—On June 12th, 1903, in company with an assistant, I made an examination of portions of the East ½ of the N. W. ¼; S. W. ¼, N. E. ¼; N. E. ¼, S. W. ¼; and E. ½, S. W. ¼ of Sec. 2, T. 35, R. 8W., in reply to a petition submitted January 24, 1903.

This land is mainly underlain with Gasconade limestone, although the ridges and ravines, in a number of places, display some sandstone belonging to the overlying St. Elizabeth formation.

A few pieces of galena have been picked up in the overlying soil, but none of the galena so found was in the rock.

It is possible that some of the crevices which show at the surface may carry galena at a greater depth. This can only be demonstrated by sinking shafts or drilling into the formation. It cannot be said that there are any especially favorable conditions at the surface and one is led to doubt the advisability of prospecting by sinking shafts, unless a place with more favorable indications should be found.

Very sincerely,

E. R. BUCKLEY.

EXAMINATION OF LANDS NEAR BUCKLIN.

Mr. G. L. Joyce, Attorney-at-Law, Bucklin, Mo.:

Dear Sir—In accordance with a request made by yourself and others living in the vicinity of Bucklin, I have made an examination of secs. 1 and 12, T. 57, R. 18W., and secs. 7 and 8, T. 57, R. 17W.

From such examination of the surface as I was able to make, I am led to believe that all of that area between the east line of secs. 6 and 7 and the township of Bucklin, is favorably situated for the occurrence of coal. It is impossible for one to say how many or how thick the veins, underlying this area, may be. These facts can only be determined by drilling or sinking shafts. I believe that systematic prospecting with a core drill, would be the most advantageous way to prove this territory.

This is a matter which should interest every one in your city and that portion of the country tributary to it. The situation of the land and the surface indications are such as to warrant your people in making some concerted effort to have the land prospected.

If I can be of any further assistance to you in this matter, I will appreciate having you call on me.

Very respectfully yours,

E. R. Buckley.

REPORT ON PETITION FROM SHELDON.

Dr. C. C. Brand, Sheldon, Mo.:

Dear Sir—In compliance with a petition signed by yourself and other freeholders of Vernon county, I made an examination of the following described lands, for the purpose of ascertaining if there were any evidences of metallic ores, coal, asphaltic rock, oil or gas.

N. W. ¼ sec. 18, T. 34, R. 29; S. E. ¼ of S. W. ¼ and S. ½ of the S. E. ¼ and N. E. ¼ of S. E. ¼ and S. E. ¼ of N. E. ¼ and the N. W. ¼ of the S. W. ¼, S. W. ¼ of S. W. ¼, S. W. ¼ of N. W. ¼, S. W. ¼ of N. E. ¼, N. W. ¼ of S. E. ¼, N. W. ¼ of N. E. ¼ and N. E. ¼ of N. W. ¼, sec. 27, T. 34, R. 30W. and S. W. ¼ of the S. E. ¼ of sec. 12, T. 34, R. 30W.

The only mineral resources of this area which can be reported as a result of this examination, is asphaltic sandstone which underlies a considerable portion of the area examined. Shallow drill holes in the N. E. ¼ of the S. W. ¼, sec. 24, T. 34, R. 30W., show 27½ feet of asphaltic rock. This rock begins about 12 feet below the surface at the place where the holes were drilled. In the draw or ravine leading up to the drill holes, the asphaltic or bituminous sandstone outcrops at the

surface. At one place it has been quarried to a depth of several feet. There was considerable rock on the dump, most of which was heavily impregnated with bitumen or asphalt. At this place a hole had been drilled 1135 feet deep and it is reported that 32 feet of asphaltic rock was passed through near the surface.

An excavation in the creek bed in the N. W. ¼ of sec. 18, T. 34, R. 29W., reached the bituminous or asphaltic sandstone. Near this place, on a farm owned by Hall and Popplewell, there is a well, the bucket of which is coated with asphalt which evidently seeps out of the rock and rises to the surface of the water in the well. This well is 27 feet deep.

In the S. W. ¼ of the S. E. ¼ of sec. 12, T. 34, R. 30W., a seam of coal was examined which is rich in bitumen. The seam occurs about 10 feet from the surface, is 22 inches thick and is overlain with sandstone. Wherever the coal is encountered in this region, it is from 12 to 36 inches thick.

A hole had been bored in the S. E. ¼ of the S. W. ¼ of sec. 27, T. 34, R. 30W., to a depth of 1306 feet. At a depth of 15 to 16 feet bituminous or asphaltic sandstone was encountered. The asphaltic sandstone is reported to be 21 feet thick and underlain with 17 feet of fire clay.

In the S. W. ¼ of S. W. ¼ of sec. 27, T. 34, R. 30W., bituminous or asphaltic sandstone outcrops along the sides of a bluff and near the heads of the ravines. During warm weather the bitumen is reported to ooze out along the bedding planes of the exposed rocks. Two small shafts sunk in the rock each show sandstone heavily impregnated with asphalt. Near the line of sec. 28, the bituminous sandstone outcrops within two feet of the surface. Two shafts which have been sunk in this sandstone are partly filled with water, on top of which the bitumen floats in considerable quantity.

From an examination which was made in this locality, I am convinced that there is an almost inexhaustible supply of bituminous or asphaltic sandstone of good quality. I believe that in some places the sandstone is sufficiently rich in asphalt to warrant the erection of a plant for the extraction and preparation of the asphalt for commercial uses. The early development of these deposits of asphaltic sandstone will depend quite largely upon the attitude assumed by the owners of the land toward those who wish to make developments. This is a comparatively new field and in order to interest those who have capital, the land owners must assume a generous policy.

Respectfully submitted,

E. R. Buckley.

REPORT ON PETITION FROM HARVIELL.

Mr. L. Knickerbocker, Naylor, Mo.:

Dear Sir—In compliance with a petition signed by yourself and other citizens of Naylor, I made an examination of certain lands in the vicinity of Harviell, Missouri, on which prospecting was being carried on. Such examination as I was able to make, led to the conclusion that insufficient development had been done to warrant an expression of opinion relative to the probable occurrence of lead or zinc ores. The two shafts are not sufficiently deep for one to determine the character of the formation in which they have been sunk. The presence or absence of valuable minerals cannot be shown except through systematic prospecting over a considerable area and to greater depths than that to which the present shafts have been sunk.

Respectfully submitted,
E. R. BUCKLEY.

REPORT ON LANDS IN THE VICINITY OF MONTICELLO.

Judge F. L. Marchand et al., Monticello, Mo.:

Gentlemen—In answer to a petition received August 13, 1904, I have made an examination of the lands described in said petition and would respectfully report as follows:

Either coal or carbonaceous shale were found at three different places on the land inspected. These deposits occur in the N. W. ¼ of the N. W. ¼ of the N. W. ¼ of sec. 5, T. 61, R. 7W.; in the S. W. ¼ of the N. W. ¼ of the N. W. ¼ of sec. 5, T. 61, R. 7W.; and in the middle of the W. ½ of the N. E. ¼ of the N. E. ¼ of sec. 5, T. 61, R. 7W. At the locality first described, there is a thickness of from 14 to 48 inches of bituminous coal, of very good quality. At the other two localities, no coal was observed. The shale and coal both occur at practically the same elevation. Coal was reported to have been found near the line between the S. E. ¼ and the N. E. ¼ of sec. 30, T. 62, R. 7W., and near the east line of the N. E. ¼ of the N. W. ¼ of sec. 5, T. 61, R. 7W. At the time of my visit, neither coal nor shale were found at these places, probably as a result of the valleys having been filled with sand and silt as a result of the recent heavy rains.

Information gathered relative to deep well borings near the exposures of coal and shale, indicates that coal does not underlie the more elevated land west and north of the coal mine. This is confirmed by observations made on the outcroppings of rock in the immediate vicinity of the coal mine. If the coal seam extended over a considerable area, it would

outcrop at numerous places along the branches at the same elevation, since the beds lie practically horizontal. As it is, I observed sandstone at the same elevation as the coal in many places on the land owned by Mr. Smith and others in the vicinity of the mine. On Thomas Johnson's land, there is an exposure of carbonaceous shale, but on either side and within a few rods, there are thick beds of sandstone where the shale should be, if it continues uninterruptedly through the hill. On the land owned by Mr. Sayre, there is an outcrop of shale in a branch. This shale is local as is shown by the way it pinches out against the sandstone as it is followed up the branch.

Every evidence, both in the coal mine and outside of it, points to the fact that the deposit of coal in the N. W. ¼ of the N. W. ¼ of the N. W. ¼ of sec. 5, T. 61, R. 7W., is a so-called pocket and does not continue underneath the prairie land to the west and north. The amount of coal in the pocket can only be determined by drilling outside of the known limits of the coal. I not only believe that the coal seam is limited in extent, but I also believe that there is no coal seam beneath the one now being worked.

I think you would be justified in drilling a few holes immediately around the coal mine, within a radius of 100 feet, in order to determine the actual amount of coal in the deposit. These holes should not exceed 100 feet in depth. If you should find coal in the holes drilled within a radius of 100 feet of the mine, then I would suggest that you drill other holes 200 feet from the mine. In this way you can determine very closely the amount of coal in the pocket which you are now mining.

Respectfully submitted,

E. R. BUCKLEY.

Director and State Geologist.

REPORT ON PETITION FROM GOLDEN.

Mr. Henry Clay et al., Golden, Mo.:

Gentlemen—In answer to your petition, the following described lands were examined on September 11 and 12, 1903, viz: the N. E. ¼ of the S. W. ¼ and the S. E. ¼ of the N. W. ¼ of sec. 18, T. 21N., R. 25, owned by Mr. Henry Clay and the S. E. ¼ Sec. 6, T. 21, R. 25, belonging to Mr. L. L. Wall.

The general topography of the country is very rough. At this place the White river flows northeast, in a channel 150 to 250 feet below the tops of the surrounding hills. The land examined lies at one of the lowest points in the district, being practically surrounded by hills which rise from 500 to 700 feet above the river level. The drainage diverges at this place to the west, north and south, as shown by Roaring

river which flows west, Rock creek south and Owl creek north. Owl creek, which flows along the west side of the Clay prospect, has a large catchment basin to the south.

The surface rock consists of "cotton rock," dolomite and flint belonging to the Cambro-Ordovician succession. The dolomites, in general, are fine grained and compact. A ten-foot bed of sandstone occurs in the strata about 25 feet above the bed of Owl creek, near the Clay prospect. The beds are approximately horizontal and in no place exhibit marked deformation. The beds have a slight general dip to the north and are gently folded. The joints are, as a rule, tight. One normal fault, having a displacement of 3 feet 8 inches was observed in the bluff just west of the shaft. It dips 27° to the south and strikes N. 70°W. Apparently this fault is not accompanied by brecciation.

On the hillside east of the shaft, occurs a rather thin brecciated or porous bed of flint, out of which, during rainy weather, water seeps. Occasionally crystals of zinc blende or "jack" occur in this bed.

The development work at this place consists of one combined shaft and drill hole, 100 feet deep, and one drill hole 40 feet deep. The 40-foot drill hole is just east of Owl creek, while the shaft is 250 feet east of the creek and 35 feet above the creek bed. The shaft is located on a continuation of the fault mentioned above. The following section shows the succession of beds passed through in the shaft and drill hole as recorded by Mr. Clay. The cuttings from the drill hole were not available for examination and the section could not be verified below the depth of the shaft. In the shaft zinc blende was found in only one bed as hereinafter noted.

No. 1.	Drift	2½ ft.	
" 2.	Sandstone	10 ft.	
" 3.	Mud opening	8 ft.	
" 4.	Fine grained dolomite	16 ft.	
" 5.	Fine grained dolomite	2½ ft.	No shines.
" 6.	Gray rock	3 ft.	Shines.
" 7.	Gray rock	3½ ft.	Lead and jack.
" 8.	Flint	3 ft.	Jack shines.
" 9.	Gray flint	4 ft.	Jack, copper and lead shines.
" 10.	Blue flint	3 ft.	Jack and flint.
" 11.	Gray rock	3½ ft.	Few shines.
" 12.	Gray rock and flint	6 ft.	No shines.
" 13.	White flint	1½ ft.	Quartz and mundic.
" 14.	Flinty white rock	1½ ft.	No jack.
" 15.	White and brown rock	4 ft.	Jack.
" 16.	Brown rock	5 ft.	Quartz and considerable jack.
" 17.	Brown rock	2 ft.	Good jack.
" 18.	White rock	2 ft.	Quartz and jack.
19.	White rock and flint	1½ ft.	No jack.
" 20.	White and blue flint	4½ ft.	Quartz and hard formation.
" 21.	Gray rock	4 ft.	Few shines of lead and jack.
" 22.	Gray rock	4 ft.	Supposed galena.
" 23.	Gray rock	1 ft.	Jack.

The two beds marked Nos. 16 to 18 and 22 and 23 reported as containing jack are soft rock. Just above the upper bed occurs a very fine grained compact ledge known locally as lithographic stone. Above the lower beds there is a very hard dense bed of flint. The mineral is reported as occurring in the soft stone just beneath these beds. The shaft has been sunk to the fine grained cap rock just above the first reported mineral bed. The upper portion of the shaft is practically barren. A thin bed containing crystals of pink dolomite and zinc blende was passed through at the level of the creek bed. This stratum containing pink dolomite and blende shows in the creek bed. For 30 feet, the shaft shows a fault with a displacement of one foot. The dip of the fault carries it outside of the shafts about 10 feet from the bottom. It is reported that small crystals of blende were found along this fault. Underground water conditions seem to indicate that the stratum directly underneath the fine grained rock at the bottom of the shaft is porous.

A thin bed of flint from 2 to 3 inches in thickness occurs 10 feet from the bottom of the shaft. This bed has been assayed by different assayers and has shown a large range of value in gold and silver. Assays made by this department, give the following results. Gold 0.00. Silver .48 Oz. per ton.

A number of the beds of limestone contain considerable asphaltic material.

Conclusion.

No indications of extensive mineralization were observed on the surface of the hills. A few small crystals of blende were found where single shots had been placed in the hillside. Very little loose mineral occurs at the surface. There is no indication of porous, broken or open strata above the present water level and there is little liability of extensive mineralization throughout this portion of the formation. The location of the shaft on this property is one of the best that could be made in this vicinity, being located on the above mentioned fault. In order to test the richness of the cuttings, I would advise sinking the shaft to the depth of the drill hole. This would be a matter of a small cost and will make a very good test of this ground.

The thin bed of flint, which was reported as quartz, does not contain enough silver to make it a commercial proposition.

Although asphaltic material occurs in a number of the beds, no indication was found that beneath the present level, there are extensive deposits of oil and gas.

Mr. Wall's Land.

The land owned by Mr. Wall is located just south of the White river in the E. ½ of the S. E. ¼ of sec. 6, T. 21, R. 25. The same strata occur at this point as at the Clay prospect. Two shafts have been sunk upon this property,—one near the river and the other in a small ravine northeast of the house. These shafts were partly filled with water and an examination was impossible. From the material on the dumps the same succession of strata was apparent as at the Clay prospect, but neither shaft has been sunk to the depth of that on the Clay land. The beds are fine grained and show very little mineral.

Upon the hillsides, above the river, boulders of hematite were found but not in sufficient quantity to be of commercial value.

CONCLUSION.

The same general conditions exist at this property as at that of Mr. Clay, and should the shaft be sunk to the same depth probably the same conditions would be found at both places. No faulting was noted in this vicinity.

Respectfully submitted,

H. A. BUEHLER,

Assistant State Geologist.

REPORT ON PETITION FROM ALBANY.

Mr. C. N. McNeese et al., Albany, Mo.:

Gentlemen—In answer to your petition addressed to the State Geologist, I examined, on the 5th and 6th of October, 1903, the following described lands, to wit: the N W. ¼ of N. W. ¼ of sec. 20, and the N. E. ¼ of N. E. ¼ of sec. 13, all in T. 64, R. 30W.

This land is located east of the east branch of Grand river and has a rolling, hilly topography. The surface of the land is covered with a variable thickness of glacial drift, immediately underneath which lie the Upper Coal Measure strata. Owing to the thickness of the glacial drift, these rocks outcrop only along the stream channels or their branches. In this locality the Coal Measure strata consist mainly of heavy beds of shale, interstratified with thin beds of limestone. A coal seam outcrops along the north bank of McGinley branch on the land above described. This seam was worked before the war, but of late years has remained untouched. At the time this examination was made the coal seam was not exposed, but it is reported to have a thickness of

18 inches. Prior to making this examination, a new shaft was started on the hill north of the creek. This shaft was 23 feet deep at the time this examination was made, but the coal seam had not been reached. The shaft passed through about 20 feet of red clay into a sandy blue shale. Since making this examination the coal seam has been reached and samples have been forwarded to this office. In this shaft the seam is reported to be 18 or 19 inches thick, but about one-third of this is very soft. This may be due to the nearness of the shaft to the old tunnel.

A similar seam of coal was passed through in a well just north of Chalk Run on the land of James H. Hill, one mile south of the McNeese outcrop. The coal occurs at the same level but the exact thickness of the bed is not known. The strata at this point lie approximately level, and in all probability the coal bed is continuous between the two places.

The following analysis shows the composition of the coal from the shaft on the McNeese land:

Water	9.58%
Volatile Carbonaceous matter	39.41
Fixed carbon	44.48
Ash	6.53
	100.00
Total volatile matter	48.99
Coke	51.01
	100.00
Color of ash	dark brown.
Coke	firm lustrous.

This analysis shows the coal to be of very good quality.

Beneath the coal occurs a bed of blue shale, the exact thickness of which is not known. A sample taken 2 feet below the coal gave the following analysis:

H_2O, CO_2	11.12
SiO_2	55.10
Al_2O_3	27.52
Fe_2O_3	1.95
CaO	.62
MgO	1.51
	97.81

The undetermined constituents are the alkalies.

This shale is suitable for the manufacture of building brick and vitrified paving brick. It could also be used in the manufacture of Portland cement.

A bed of very similar shale, 15 feet thick, is exposed along a south branch of Muddy creek. Beneath this shale occurs a ledge of sandy limestone showing small streaks of carbonaceous material with occasional very thin stringers of coal.

At Denver, four miles north of the McNeese property, moderately heavy beds of limestone outcrop along the east branch of Grand river. The following is an analysis of a sample taken from the white bed near the mill at Denver:

Insoluble matter	2.34%
$Fe_2O_3Al_2O_3$	.62
$CaCO_3$	96.16
$MgCO_3$	.49
Total	99 61

This analysis shows the stone to be a very pure limestone which is admirably adapted for use in the manufacture of Portland cement.

CONCLUSION.

The coal outcropping on the McNeese property is of very good quality, but the vein is not thick enough to be worked economically by itself. Should a brick plant be erected at this point to use the shale underlying the coal, the two might possibly be mined at a profit.

The limestone and shale are well suited to the manufacture of Portland cement. The outcrops are about four miles apart, although the same limestone and shale probably occur in closer proximity at other points.

Since the coal and shale are both located seven miles from a railroad, it is thought that neither can be economically developed on a large scale, until transportation facilities are provided.

Very respectfully submitted,

H. A. Buehler,

Assistant State Geologist.

CHAPTER IV.

FUTURE WORK AND NEEDS OF THE BUREAU.

Examination of Specimens. It is the duty of the Director or his assistants to examine all specimens sent to the Bureau by citizens of Missouri, furnishing such information as they can relative to the kind and value of the minerals. It might be desirable for the Bureau to make free analyses and assays of specimens, were it not for the fact that the privilege would be greatly abused and that it would be an infringment upon the field of the professional assayer and analyst. As it is, the Bureau can only advise whether or not the specimens are of such a nature as to warrant analysis. In the future, as in the past, we expect to make examinations of specimens and report as to their probable value.

Chemical Laboratory. A great many analyses of rocks and ores are needed in the preparation of the reports of the Bureau. For making these analyses, the Bureau is very poorly equipped. It is hoped that in the future we may have better laboratory facilities and be thereby better enabled to perform the chemical work needed.

Laboratory for testing materials. There is a constant demand on the part of citizens of the State for the testing of materials to determine their suitability for the manufacture of quicklime, cement, brick, terra cotta, pottery, etc. The testing of cement, quicklime, stone, brick, paving materials, etc., is important and can be best carried on in conjunction with this Bureau. This is the age of brick, terra cotta and cement, and the testing of these products and the materials for their manufacture should be carried on systematically in every state. It is our desire to make these tests, but without the necessary laboratory equipment, it is impossible to do so. The Bureau has neither a chemical nor a physical laboratory or the equipment for either.

Topographic Maps. The preparation of topographic maps prior to making a geological survey of a county reduces the cost of such survey about one-half and increases very greatly the accuracy of the work. It is positive that geological work in any area should be preceded by the making of topographic maps.

Missouri has not appropriated a dollar for topographic maps during the last four years, although through a co-operative arrangement and

for the purpose of stimulating an interest in this work, the U. S. Geological Survey has mapped five sheets and has begun the field work on another. The U. S. Geological Survey has expended in Missouri during the last two years about $17,000 in topographic mapping. This is a sum almost equal to the total appropriation made by the State for all kinds of geological work for the same period.

In order to insure the continuance of topographic mapping by the U. S. Geological Survey, a specific appropriation must be made for that purpose. The United States Survey is willing to make these maps in co-operation with this Bureau, each paying one-half of the cost. Under a similar plan of co-operation, Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, West Virginia, North Carolina, Georgia, Alabama, Ohio, Wisconsin, North Dakota, Colorado, Nevada, Idaho, Arizona and Texas are having or have had topographic maps made. Pennsylvania has been appropriating annually for this work $20,000. North Carolina has appropriated $10,000 annually. West Virginia has appropriated $15,000 annually. Ohio appropriates $25,000 annually. Other states have made similar allotments of money to be used for topographic mapping in co-operation with the U. S. Geological Survey.

Among other uses of topographic maps may be mentioned the following:

1. "*Educational.*—(a) By promoting an exact knowledge of the country; (b) by serving teachers and pupils in geographic studies.

2. *Practical.*—As preliminary maps for planning engineering projects. Highways, electric roads, railroads, aqueducts and sewerage plants may be laid out on them, and the cost of preliminary surveys may be saved. Areas of catchment for water supply, sites for reservoirs and routes of canals may be ascertained from these maps.

3. *Political.*—In all questions relating to political or legislative matters. For these purposes they afford accurate information as to the relations of boundaries and towns to natural features.

4. *Administrative and Military.*—In all questions relating to Federal or State administrations of public works, as canals, reservations, parks, highways and as military base maps on which to plan works of offense, defense, camps, marches, etc.

5. *Statistical.*—As base maps for the graphic representation of all facts relating to population, industries, products or other statistical information.

6. *Economic.*—As a means for showing the location, extent and accessibility of lands, waters, forests and valuable minerals. In this re-

spect these maps are indispensable to State and Federal bureaus, and to owners, investors and corporations."

"In addition, as an incident in the making of a topographic map, monuments are established throughout the State, the positions of which are accurately determined by geodetic methods and which serve as datum points for all other Government, private and cadastral surveys. There are also established throughout the State bench marks or permanent monuments which furnish datum elevations for the future determinations of height in connection with all public or private engineering works. Meridian marks are established at each county seat, which aid local and county surveyors in determining the declination of their compasses and which thus greatly facilitate the search for old property lines."

"The maps that result from these co-operative surveys show, in different colors, both in the manuscript and in the published edition, the following principal facts:

1. Public culture, printed in black, which includes the exact plan of every road, lane, path, railroad, street, dam, public boundaries, names, etc.

2. The hydrography, or water, printed in blue, including all lakes, rivers, streams, swamps, marshes, reservoirs, springs, etc.

3. The relief, or surface forms, printed in brown, including the shapes of the hills, valleys and ravines, their elevations and depressions, and the slopes of every rise or fall in its surface of the land."

"The topographic maps produced by co-operative surveys are engraved on copper and printed from stone. The co-operating States have the benefit of this publication without further expense, and the residents of the State, as well as its officials, may purchase the maps at rates of 5 cents per sheet, or $2 per hundred." (Extract from a report of the Director of the U. S. Geological Survey.)

The United States Geological Survey will duplicate every dollar that is appropriated by the State specifically for topographic mapping. If this State were to appropriate $10,000 for this purpose the U. S. Government would spend $10,000 in addition. In this manner the topographic maps which are so valuable and necessary, both for commercial and scientific enterprises, may be obtained for one-half what they would cost if the State were to make them herself.

County Geologic Reports. The most important investigation entrusted to the Bureau is the completion of the geological survey of the State, which contemplates the preparation of complete reports on the geology and mineral resources of each county. It is the present plan to push this work as rapidly as possible, surveying first those counties for

which detailed reports have not been published. With the many other duties which the Bureau has been called upon to perform this work has progressed slowly during the last biennial period. A much larger appropriation is needed if it is desired to make these reports available within a few years. There are many counties where indications of rich mineral deposits occur, in which the prospector might be aided by such surveys as are now being made. Both the lead and zinc producing counties in the southern part of the State and the coal, clay and cement producing counties in the north would derive great benefit from the county geological reports could they be made.

Economic Reports. Reports dealing with special mineral resources and covering the entire State are very much needed. We have just issued a comprehensive report on "The Quarrying Industry" and have in preparation another volume on "The Lime and Cement Resources." Volumes treating of the "Coal Resources," "Barite," "Materials for Street Paving and Highway Constructions," "Lead," "Zinc," "Asphalt," etc., are being called for continually, but we have no reports on these subjects for distribution. A very important work for the future is the preparation of reports on these subjects.

Physical Geography. There are many requests for reports treating of the physical geography of the State. A report or a series of reports dealing with this subject would be of inestimable value for use in the public schools. The young must be educated along these lines if it is expected that the next generation will be more familiar with mining and kindred subjects than the present. There is no better way to increase the general intelligence of the public than by the issuance of reports of this character in which the illustrations are drawn from the hills, valleys, prairies and plains of our own State.

We propose in the near future, whenever there is sufficient appropriation, to publish reports of this character.

Publications. The cost of publishing the reports has, during the last biennial period, consumed a considerable part of the appropriation. There was not sufficient, after doing the necessary field work, to publish one of the reports completed. There should be a specific allowance sufficient to cover this item. The value of the reports is in a measure lessened by tardiness in issuance.

Library Cases and Furniture. Owing to the small appropriation of the last few years we have not been able to add to the library, the volumes needed for reference in the preparation of our reports. The work of the Bureau would be assisted by the addition of much needed books. We

have several hundred volumes of unbound United States and foreign reports which should be bound.

The furnishings in the Bureau, which include carpets, cases, tables, chairs, etc., have been in use for fifteen years and are now nearly beyond the stage of repair. A small appropriation is needed for furnishing the offices, library and museum.

In General. The greatest efficiency can be secured by granting a sufficient appropriation to carry on, without hindrance or delay, the work, for which the Bureau was created.

Estimates of Appropriation Needed for 1905-6. To carry out the provisions of the law creating the Bureau of Geology and Mines, as outlined in Chapter 110 of the Revised Statutes of Missouri for 1899 and the Amendment thereto, passed by the 41st General Assembly, the Board of Managers consider it necessary that the following appropriation be made:

For maintenance and support, including salaries and expenses of State Geologist, assistants and clerk	$27,000
For supplies, equipment—including instruments used in the field—and apparatus for the chemical and physical laboratories	5,000
For topographic mapping in co-operation with the U. S. Geological Survey	10,000
For printing, engraving and preparing maps and other illustrations for reports	7,000
Total	$50,000

CHAPTER V.

THE MINERAL RESOURCES OF MISSOURI.

During the biennial period just past the output of the mines, quarries and clay working plants has kept pace with the developments in agriculture and the manufactures. Missouri still maintains her rank among the foremost mining states of the Union. She ranks first in the value of zinc and barite mined; second in the production of lead; seventh in the production of clay wares; sixth in the production of limestone; and twelfth in the production of coal. The value of the mining products for 1903 was nearly 30 millions of dollars distributed as follows:

*Zinc	$6,790,214
*Lead	6,164,774
**Coal	6,913,444
Barite	102,822
**Clay Products	5,661,607
Building Stone, Quicklime, Sand, Tripoli, etc	2,521,016
Iron ore	106,388
Petroleum and Natural Gas (estimated)	11,000
Cement (Portland) (estimated)	1,200,000
	$29,471,265

*Lead and Zinc Mine Inspectors Report, 1903.
**Mineral Resources of the United States, U. S. Geological Survey, 1903.

Bulletin No. 9 of the publications of the Census Bureau reports that there were 1,045 operating and 32 partly developed mines and quarries in Missouri in 1903. In these mines and prospects there were 16,900 employees, receiving about $10,200,000 in salaries. There was paid for supplies and miscellaneous expenses $5,003,031. The total paid for wages and miscellaneous expenses was approximately $15,200,000. The value of the products considered in that report amounted to $20,-284,655. Substracting the disbursements from the value of the product we have about $5,000,000, representing the addition made to the permanent wealth of the country through the production of the Missouri mines in 1902. In the total value of the mineral products for 1902, as reported by the Census Bureau, Missouri is eleventh among the states of the Union. She is exceeded in the total value of her mineral production only by, Pennsylvania, Ohio, Michigan, West Virginia, Colorado, Illinois, Montana, Indiana, California and Minnesota.

ASPHALT AND ASPHALT ROCK.

The deposits of bituminous sandstone and limestone, referred to in the last biennial report as occurring in the western part of the state, have not yet been developed. At Liberal the bituminous (asphaltic) sandstone is quarried for sidewalks, curbing, etc., but up to the present time it has not been used for paving. Neither has any attempt been made to separate the asphalt from the rock.

The bituminous sandstone which occurs near Sheldon has been prospected sufficiently to show that it occurs over extensive areas. It has been tested sufficiently to warrant one in saying that it is of good quality. The percentage of bitumen or asphalt in the stone frequently reaches 12 to 15 per cent and there is every reason to believe that it constitutes a good material for making rock asphalt pavements. For more detailed information about the asphaltic sandstone near Sheldon the reader is referred to Chapter III., in which there is a report on lands in that locality.

BARITE.

Barite, ($BaSO_4$), barium sulphate, is known by the miners and others as "ball tiff," "tiff," "heavy spar" and "spar." It occurs in many places throughout the Ozark region, chiefly associated with galena in the Cambro-Ordovician dolomites. The output in 1903, according to statistics gathered by this department, amounted to 26,069 tons, valued at $102,822.41. The only mines reporting an output for that year are located in Franklin, Washington, Jefferson and St. Francois counties. Miller, Morgan, Cole, Camden and Hickory counties have each produced barite in years past, but none of these reported an output for 1903.

The barite mines are shallow, seldom extending beyond the depths to which the clay seams can be followed. In many of the mines the barite occurs, associated with crystallized galena, known as "cog mineral," and is mined as a by-product.

Both the barite, and the galena with which it is associated, occur embedded in a tough, red clay, from which it is separated mainly by hand. The barite is graded roughly, according to the percentage of iron which it contains, into No. 1 and No. 2. The No. 1 barite is a clean, white product, while the No. 2 is stained a light reddish brown with iron oxide and clay. After leaving the discolored barite exposed to the rains for several months much of the iron oxide and clay are washed away. In this way the grade of the barite is frequently raised from No. 2 to No. 1.

During the last year "The Point Mining and Milling Company" has purchased 300 acres of barite land in Washington county and has erected a mill, at Mineral Point, in which the finest grade of floated barite is produced. The capacity of the mill is 25 tons of refined barite per day. The mill is situated in the center of the Barite region and should never lack for crude ore on which to run.

Barite mining in this state is carried on in a very desultory manner. The mines consist of hundreds of shallow shafts which are usually worked on a royalty. Some of these shafts are connected with drifts which have been worked and re-worked many times. Many of the farmers in the district work the shallow mines at odd times bringing the barite to market the same as they do wood.

The veins which occur in the undecomposed rock have scarcely been uncovered. These will some day supply the demand which is now met by the barite from the clay seams and the residual clay.

BUILDING STONE.

During the last year, this department has published a comprehensive report descriptive of the quarrying industry of Missouri. This report includes a description of all the important quarries in the state; a treatise on the demands, uses and properties of stone; tables giving the strength of Missouri stone as compared with that from other well known quarries in the United States; and other valuable information relative to the demands and uses of stone. The following table, copied from page 326 of that report, gives the production of stone for Missouri in 1903, as obtained from reports furnished this department by the different operators.

TABLE NO. XII.

PRODUCTION OF STONE IN MISSOURI FOR 1903.

Limestone.		
Rubble	194,352 perch	$230,721 00
Crushed	1,115,872 cu. yds.	*265,824 19
Cut	397,042 cu. ft.	265,991 97
Rip Rap	159,440 cu. yds.	138,658 44
Miscellaneous uses		129,963 59
Quick Lime	1,097,281 bbls	422,781 82
Total limestone products		$2,053,941 01
Granite.		
Crushed	30,000 tons	†$30,000 00
Monumental	34,000 cu. ft.	26,175 00
Spalls	1,540 tons	1,350 00
Paving Blocks	785,506	19,870 00
Curbing	13,000 ft.	2,405 00
Total		$79,800 00

*The railroads used 479,705 cu. yds. of crushed stone, valued at $239,852.50, the greater part of which is included in the returns received above.

†Incomplete returns.

Tripoli.

75,000 filters		
3,180 tons ground		$90,000 00
900 tons crude		

Sand.

Glass and Moulding	114,894 tons	†$59,163 00

Sandstone.

Miscellaneous		34,423 17

Chats.

Railroad Ballast	407,378 cu. yds.	203,689 00
Other uses not estimated		
Total production of quarry products		$2,521,016 18

The United States Geological Survey report on the Mineral Resources gives the value of the output from the Missouri quarries in 1903 as $2,716,499.

†Incomplete returns.

In the southeastern part of the State, chiefly in Madison and Iron counties, there are extensive deposits of red granite. The stone from the granite quarries is suitable for all kinds of building constructions. It is hard, strong and durable. It takes a brilliant polish and is unsurpassed by few red granites for monuments and interior decorative purposes. When crushed, the granite makes an excellent material for macadam pavements or for use in concrete work. The curbing and paving blocks which are manufactured from this granite are more costly than limestone, sandstone and many of the foreign granites, but they are superior in strength and durability.

One of the most abundant stones in this state is limestone, the value of the product from which, exclusive of quicklime, amounted in 1903, to over $1,600,000. The limestone from many of the quarries is of excellent quality, specially suited for building purposes. The quarries at Carthage, Cape Girardeau, Hannibal, Phenix and Springfield contain some of the very best and most durable limestone in the United States.

The following table gives the results of tests made on the Carthage limestone as published on pages 131 and 132 of the report on "The Quarrying Industry."

Physical Tests.—Two inch cubes of limestone from Carthage were tested in the laboratory with the following results:*

*Material furnished by the Carthage Marble and White Lime Co.

Specific Gravity		2.708	
Porosity		1.244	per cent.
Ratio of Absorption		0.502	
Weight per cubic foot		167.	lbs.
Transverse Strength		2,285.5	lbs. per sq. in.
	(a)	14,270.6	lbs. per sq. in. on bed.
		11,879.	lbs. per sq. in. on edge.

Crushing strength	(b)	16,337.	lbs. per sq. in. on bed.
		15,396.	lbs. per sq. in. on edge.
	(c)	12,741.3	lbs. per sq. in. on bed.
		12,684.	lbs. per sq. in. on edge.
	(d)	17,777.	lbs. per sq. in. on bed.
Crushing strength of samples subjected to	(a)	13,382.7	lbs. per sq. in. on bed.
freezing test	(b)	15,865.0	lbs. per sq. in. on bed.
	(c)	13,921.0	lbs. per sq. in. on bed.

(a) Samples free from suture joints.
(b) Samples containing suture joints from ½ in. to ¾ in. in depth.
(c) Samples containing fine suture joints. Coarsely crystalline.
(d) Samples of free stone. Maximum crushing strength 20,261 lbs. per sq. in.

Three sets of specimens were used for determining the strength of the fresh and frozen samples, the results of which are given above. It will be observed that in the first case (a) the strength of the frozen samples was 887.9 pounds per square inch less than that of the fresh samples; in the second case (b) the frozen samples tested 472 pounds per square inch less than the fresh samples; and in the third case (c) the strength of the frozen samples was 1179.7 pounds more than that of the fresh samples. These tests were made upon stone which was free from suture joints and on pieces containing suture joints. The results seem to indicate that the stone suffers comparatively little injury from alternate freezing and thawing.

The slight difference between the ultimate strength of this stone on bed and on edge, as shown in all three cases, proves conclusively that there is no danger from placing the stone on edge in constructional work.

The weight of the stone as computed from the specific gravity and porosity determinations is somewhat lower than the weight of the stone as it comes from the quarry. A block containing about one cubic foot of stone, tested in the office of the Carthage Marble and White Lime Company, weighed 170 pounds. This, for commercial purposes, may be taken as the weight of the stone.

The manufacture of quicklime is one of the important industries in Missouri and for this purpose the Burlington and Trenton limestones are unexcelled. The quicklime industry will be the subject of a special report to be issued by this Bureau sometime during the next two years. In this report the distribution of limestone suitable for the manufacture of quicklime will be considered, as well as the qualities of the different quicklimes produced from the limestone from the different formations. The importance of this industry in Missouri is shown by the output, which, in 1903 was valued at nearly a half million dollars.

The sandstone quarries in this state are, with two or three exceptions, small, and the product is used chiefly for local consumption. The

quarries at Warrensburg and Miami are large and the stone is valuable both for building purposes and for the manufacture of grindstones. The stone from these quarries finds a ready market in the southern states, to which most of the product is now being shipped. The yellow and brown colored sandstones which occur throughout the Ozark region are strong and durable. They constitute a very desirable material for sidewalks, crosswalks, curbing and foundations. As far as strength and durability are concerned, they are desirable building stones, but their color is seldom uniform and therefore not desirable for buildings.

The St. Peters sandstone which is known as the Saccharoidal, Crystal City and Pacific, is in many places almost pure silicon dioxide. It is soft and friable and can often be broken down with a pick and shovel. It occurs in unlimited quantities near Pacific, where three companies are working quarries from which each ships in the neighborhood of three car loads of sand per day, most of which is used in the manufacture of glass. The Pittsburg Plate Glass Co., at Valley Park is using three car loads of this sand per day. It is reported by those experienced in glass making, that this is superior to any sand which is being quarried in the United States. Sand of as good quality occurs in unlimited quantities at Klondike and Crystal City, at each of which places it is extensively quarried.

Sand is one of the very necessary materials used in all kinds of masonry construction. It is obtained from sandstone quarries, from banks along rivers and streams, from lake shores, from glacial deposits, from sand dunes, and from vein quartz and quartzite by crushing. It is difficult to estimate the quantity of sand used in this state. As a rule none but the largest companies keep a record of their sales. The estimate of approximately $60,000 for sand in the manufacture of glass and for moulding, is very low. The probability is that these figures should be doubled.

The U. S. Geological survey report on the "Mineral Resources" gives the value of sand used in Missouri in 1903, for glass making, engine and furnace uses and for building, as $128,036.

CHAT.

The tailings which result from the concentrating of the blende and galena mined in the southeastern and southwestern parts of this state, are commonly known as chat. This chat is now being used in great quantities by the railroads for ballast and in the construction of concrete piers, abutments in bridges and culverts It is also used extensively in cement curbs and gutters. This chat consists chiefly of crushed flint and

limestone and thousands of tons of this material may be had in Jasper, St Francois and Lawrence counties.

It is thought that the chat might be used in the manufacture of artificial stone, electrical conduits and sewer pipes.

CLAY PRODUCTS.

According to statistics published in the U. S. Geological Survey report on "The Mineral Resources," Missouri ranks seventh among the states in the value of her clay products in 1903. Our records show that in 1903 there were approximately 250 factories in this state manufacturing brick, tile, terra cotta, sewer pipe, pottery, fire proofing and other clay products. The following is a summary of the value of the clay products manufactured in this state in 1903 as given in the U. S. Geological Survey report referred to above.

Common Brick	1,725,253
Front Brick	333,965
Vitrified Paving Brick	307,965
Ornamental Brick	39,756
Fire Brick	925,915
Drain Tile	45,363
Sewer Pipe	1,050,794
Ornamental Terra Cotta	871,006
Fire Proofing	91,533
Hollow Building Tile or Blocks	7,355
Tile (not drain)	235,091
Miscellaneous	409,355
Pottery	51,401
Total	5,661,607

The above report shows an increase in the value of clay products since 1901 of over $1,000,000.

Brick, tile, terra cotta, cement and stone are the building materials of the future. The supply of raw materials in Missouri, for the manufacture of clay products, is unlimited and as the demand for these products increases, there will be a proportionate development of the clay industry. At the present time the value of these products in this state is only exceeded by those of lead and zinc.

The search for clay deposits suited for the manufacture of the great variety of clay products now in use, is constantly going on.. We receive at this office, many inquiries relative to the location of clays suitable for the manufacture of different kinds of clay wares. Many samples of clay are received for examination and as rapidly as possible we are assuming a position where we can be of service to the state in pointing out to prospective manufactures the location of desirable clay deposits. The abundance and variety of clays in this state, are surpassed by few if any in the Union. The proximity of the clay banks to coal

mines, the nearness to the markets and the excellence of shipping facilities make the possibilities of the industry in this state very great.

Ohio, New York, Iowa and Wisconsin have laboratories equipped for testing both clays and clay products. It is equally as desirable and important that this state should provide a similar laboratory. The experimental work required is in line with the investigations carried on by this Bureau and it is hoped that an appropriation may be made to equip and maintain a laboratory for this purpose.

COAL.

Missouri ranks twelfth among the coal producing states. The report on the Mineral Resources of the United States, published by the United States Geological Survey, gives the output of coal in Missouri for 1903 as 4,303,332 short tons valued at $6,913,444. The coal is chiefly bituminous and is used mainly for steam and household purposes. According to Bulletin No. 9 of the Census Bureau there were 384 corporations and individuals engaged in mining coal in this state in 1902. One company produces one-fourth of the total output while over one-half of the total output is produced by ten companies. The counties producing over 100,000 short tons, in order of their importance, are Macon, Lafayette, Randolph, Bates, Adair, Ray, Vernon, Barton and Putnam.

The approximate surficial distribution of the Pennsylvanian series, which includes all the Coal Measures strata, is shown on the general geological map, which accompanies this report. Winslow estimated the maximum thickness of the Pennsylvanian at 1900 feet in the northwestern part of the state. The dip to the west and northwest has been estimated at aproximately ten feet to the mile.

The Pennsylvaniaan, (Upper Carboniferous) is subdivided into either two or three groups, either Missourian (Lower) and Des Moines (Upper), or Lower, Middle and Upper. The series as a whole consists of beds of shale, sandstone and limestone. The lower beds are chiefly shale and sandstone, the middle contain some limestone of a shaly nature, while the upper beds are chiefly limestone. The limestone gradually increases in importance towards the top of the series.

Mr. B. F. Bush, in a paper read before the American Institute of Mining Engineers, states that there are a total of twenty-nine seams or coal horizons recognized from the base to the top of the Pennsylvanian series in this state. The most important seams occur in the middle beds and from these a greater part of the coal in Missouri is mined. The seams in the Upper Coal Measures (Des Moines) are very thin and have only been worked in a small way in Nodaway and Atchison counties.

Up to the present time coal mines have not been opened at any considerable distance from the railroads, transportation facilities being very essential to their profitable development. There are thousands of acres of land which remain unprospected and from which the future coal production of this state will be obtained.

During the last year the Rich Hill area has been practically abandoned, the ground having been reported as being worked out. At the same time a new field has been opened up to the west and southwest, in the neighborhood of Sprague. Drill holes in the vicinity of Stotesburg and elsewhere show a very good vein of coal at a moderate depth.

Considerable interest has been manifested in the deposits of coal in Morgan, Moniteau and Miller counties. The deposits in these counties are, in some instances, of phenomenal thickness but they usually occupy a depression in the underlying limestone formations, on account of which they do not persist over very large areas. The coal in these pockets is both bituminous and cannel, usually of good quality. Several of these coal pockets are being developed on quite a large scale. To the Simpson Coal bank, in Moniteau county, now owned by the Monarch Coal and Mineral Company, the Chicago, Rock Island, and Pacific Railroad is building a spur about seven miles long.

COPPER.

For many years copper has been known to occur at a great many localities throughout the Ozark region, chiefly associated with the deposits of brown iron ore. In 1848 and '49, copper was mined at a place called Copper Hill in Crawford county. Mines were also opened up at an early date in Ste. Genevieve county and prospecting has been carried on near Eminence in Shannon county. None of the deposits are very large, although some of them are comparatively rich.

The most active developments in this State, have been carried on by the Copper Mountain Mining Company, at their mines in Crawford county about four miles southeast of Sullivan. This company is working a deposit of carbonate and sulphide ores which is reported to have been mined for copper in 1848 and '49. The company has a concentrating mill and smelting plant at the mine and is preparing to handle the ore in the most economical manner.

It is difficult to predict the size of this deposit, although the shafts which have been sunk and the drifts which have been run, indicate that the deposit is sufficiently large to run a small matte furnace for some time.

A copper deposit occurs near Ste. Genevieve, which is evidently of some importance. Although it is not being developed at this time, it

will probably be exploited as soon as the market for copper is favorable.

Another deposit of copper ore occurs in Shannon county. The extent of this deposit can only be determined by drilling the land adjacent to the ores which are now exposed. It is possible that a workable deposit of copper occurs at this locality.

There is reported to be a good seam of copper ore at the old copper mine on the Mine La Motte ėstate. Up to the present time very little work has been done at this place. Under favorable conditions, the copper and the lead with which it is associated, might be exploited with profit.

There are a great many deposits of mixed corbonate and sulphide copper ores associated with the iron ore banks throughout the Ozark region. Some of these deposits may be of workable size, although thus far they have not been developed sufficiently to warrant expressing an opinion as to their value.

IRON ORES.

During 1903 there were twenty-five to thirty different companies and individuals mining or opening up banks of iron ore in this state. From reports furnished this Bureau the output for 1903 is shown to be 51,541 short tons valued at $106,388 47. The output of a number of the mines was not reported, on account of which this figure is an underestimate.

Two furnaces were operated in the state in 1903, one by "The St. Louis Blast Furnace Co.," at Carondolet, and the other by "The Sligo Furnace Co.," at Sligo. The St. Louis Blast Furnace Co. received approximately 31,500 tons of ore from Iron Mountain, obtained chiefly from the old dumps which they have been cleaning up. They also received about 19,500 tons of brown hematite from various other localities in the State. The Sligo Furnace Co., purchased their own ores, chiefly from the Lake Superior district. Only a small tonnage was purchased from Missouri mines. At present this company is operating mines at Cherry Valley and Steelville and these mines, with an average output of about 200 to 250 tons per day, furnish all the ore which they use.

The iron mines that are being worked are all located in the area underlain with Cambro-Ordovician or pre-Cambrian rocks. Franklin, Maries, Crawford, Phelps, Dent, Iron, Howell, Shannon, Carter, Ripley and Butler counties have been the principal producers. The deposits in Greene and Christian counties have been under investigation and a company has been organized to exploit them.

The iron ores of the Ozark region are chiefly soft red, hard red and blue specular hematite, although relatively large deposits of limonite or brown hematite occur associated with the dolomite and chert. The red and specular hematites are usually associated with the sandstone formations.

There is no evidence that the bodies of iron ore in this state are anywhere comparable in size with the deposits of the Lake Superior region. There are, however, numerous deposits of both red and brown hematite, of excellent quality, which are large enough to justify exploitation on a small scale. It is anticipated that during the next few years the output will be greater than it has been for several years.

LEAD AND ZINC.

The only producing lead and zinc mines in this state are located south of the Missouri river. The mines of Jasper, Newton and Lawrence counties in the southern part of the State and those of St. Francois and Madison counties in the southeastern part, are the chief producers.

**Output.* During the year 1903 the lead mined in Missouri, sold for $6,212,051. With the exception of 1,438,000 pounds of cerrussite (lead carbonate), known to the miners as "dry bone," and a few hand specimens of anglesite (lead sulphate), the lead was in the form of galena. The average selling price of the galena in the western district, (Joplin district), was $52.69 per ton, and in the eastern district, (St. Francois and Madison counties), $46.81 per ton. The average selling price of the cerrussite, all of which was mined in the western district, was $34 80 per ton.

The value of the zinc ores mined in Missouri in 1903, was $6,790,214, of which Jasper county alone produced $5,877,261. The ore is chiefly sphalerite, known commonly as blende or jack, and calamine known to the miners as silicate. The total output of silicate for 1903, was valued at $263,056 77. The average price of the sphalerite in the western district in 1903 was $33.27 per ton, while in the eastern district it sold at an average of $37.93 per ton. The silicate in the western district sold at an average of $19.80 per ton, while that from the eastern district sold at an average of $13.43 per ton.

**Extent of Mining.* In the western district, there were 7,693 men engaged in mining and prospecting for lead and zinc ores in 1903. In the eastern district, in 1903, there were 4,682 men engaged in mining, chiefly lead and zinc. The total capitalization of the

*Figures from the report of the Lead and Zinc Mine Inspectors for 1903.

companies engaged in mining these ores in Missouri, is over $57,000,000.

Compared with the other states in the union, Missouri ranks first in the production of zinc, and second in the value of her lead production. In 1904 the Joplin district is reported to have produced lead and zinc ores valued at $11,695,873, which is greater than the total production of gold in Alaska in 1903.

Distribution of Mines. According to the report of the Lead and Zinc Mine Inspectors there were twenty-two counties in the state producing lead and zinc in 1903,* while there are several other counties which are known to have mines capable of producing one or both of these ores in commercial quantities. The counties reporting a production of one or both of these minerals in 1903, are Barry, Benton. Christian, Dade, Greene, Hickory, Jasper, Lawrence and Newton in the western districts; and Camden, Cole, Crawford, Franklin, Jefferson, Madison, Miller, Moniteau, Morgan, Ozark, St. Francis, Washington and Wright counties in the eastern district. The value of the combined output of lead and zinc as given in the Mine Inspectors report for 1903 for each of these counties is shown in the following table. The counties are arranged in the order of greatest production.

Jasper	$6,990,052
St. Francois	4,309,501
Newton	543,157
Lawrence	389,790
Madison	329,172
Washington	117,517
Jefferson	64,996
Franklin	59,236
Greene	49,199
Moniteau	41,966
Ozark	10,800
Benton	9,996
Crawford	9,231
Dade	5,980
Morgan	5,130
Cole	2,982
Camden	2,592
Barry	1,973
Wright	1,911
Christian	1,827
Miller	1,500
Hickory	1,280
	$13,226,168

Permanent Character of the Lead and zinc Mining. Some people have evidently obtained a very erroneous impression as to the future of lead and zinc mining in this State and especially in the western or Joplin district. It is frequently reported,—sometimes in the columns of

our leading mining journals,—that the opening up of mines in new ore bodies is not keeping pace with the abandonment of mines already developed. It is true that the production, in tons, of ore for 1903 was less than for the preceding year. In the Joplin district such a result is not surprising to one who knows the nature of the district or to one who is familiar with the lead and zinc markets. The operators have intentionally curtailed the output at times in order to force up the market. Then there has been less advertising of the district on the part of the people interested. For these reasons the output or development has not kept up with the demand. But to reason from this that the paying ore bodies have all been discovered is very absurd. The truth is that mining has been placed upon a substantial business basis in the Joplin district. A careful examination of the Southwestern part of the State clearly indicates that there still remains a vast field for legitimate prospecting with promise of rich returns. Between the cities of Carthage, Aurora, Granby and Neck City and west to the Kansas line, there are thousands of acres of promising land which has not been prospected.

Mining in the "Disseminated Lead District," in St. Francois and Madison counties, remains steady and there is very little speculation on the part of the public as to the permanence of the ore bodies in this district. There has been some change in the management of the mines both in Madison and St. Francois counties, but the developments have gone on with practically no curtailment of the output.

In Washington, Franklin and Jefferson counties, the mines are small and the ore is obtained chiefly from the residual clay and flint at the surface or from seams in the rock. The output is chiefly galena and barite, which occur associated together.

There have been very few developments in what is known as the Central Lead and Zinc District. In Moniteau county one mine is being operated near Fortuna. The output from this mine has been comparatively steady, although the conditions do not warrant one in anticipating an increase in the output in the future. Some prospecting has been done in Miller, Cole, Morgan and Camden counties, but up to the present time no large lead or zinc mines have been developed.

Prospectors in counties adjacent to Jasper, including Dade, Lawrence, Greene, Newton and Barry, have met with some encouragement. Profitable deposits of lead-zinc ore, other than those already developed, will probably be found in the area covered by these counties.

MINERAL PAINTS.

Missouri produces small quantities of paint pigments, other than lead, zinc, barite and kaolin. The soft red hematite, some of which is

argillaceous and very finely pulverized, is sold chiefly as a paint pigment. Small deposits of very ferruginous clay, classed as umber and sienna are exploited on a small scale, but the output is not known.

MINERAL WATERS.

One of the most attractive resources of any state is an abundant supply of pure drinking water. Pure spring waters, charged with mineral salts, located amidst pleasant surroundings, attract thousands of tourists to any state. The entire State of Missouri is dotted with springs, hundreds of which, on account of their mineral content, must be classed as mineral springs. During 1902, there were eighteen mineral springs reported to the U. S. Geological Survey, as marketing mineral water. During that year, the value of the mineral water sold, amounted to $204,270.

Compared with the number of mineral springs in the State and the quality of the waters which they supply, the amount of revenue derived therefrom, is very small. This industry might be very greatly developed.

This Bureau is desirous of obtaining the location of all mineral springs within the State. It is our wish to be of assistance in making these valuable mineral springs better known among the people.

NICKEL AND COBALT.

The entire output of nickel and cobalt in this State comes from the mines near Fredericktown, in Madison county. The Mine LaMotte Lead and Smelting Company reported having on hand December 31, 1903, $276,400.00 worth of nickel, cobalt and copper matte.* Up to this time no metal or oxide has been produced. The company has a plant, consisting of roasters, smelters and refinery, for treating nickel and cobalt sulphide ores.

The North American Lead Company produced about ten car loads of nickel and cobalt sulphides during 1903.

The Catherine Mine has heretofore reported a small output of nickel and cobalt sulphides, but evidently there were none mined in 1903.

PETROLEUM AND GAS.

Prospecting for petroleum and gas during the last two years has been quite general in the western and northwestern parts of the State. The results, however, have not been very encouraging. The close proximity of the Kansas petroleum and gas field and the nearness of a very

*See Lead and Zinc Mine Inspector's report, Mo., 1903, p. 263.

excellent market, have combined to induce more prospecting than would probably, otherwise, have been indulged in.

Small quantities of both petroleum and gas have been found in many of the wells where the formation known as the Cherokee has been passed through. Wells which indicate that either petroleum or gas can be obtained in Western Missouri in commercial quantities are confined to two localities,—Belton, Cass county, and Kearney, in Clay county. At Belton there are now seven producing oil wells.

There is an extensive area in Northwestern Missouri, underlain with Pennsylvanian limestone, shale and sandstone, which has been prospected very little. Conditions favorable to the production, storage and retention of both petroleum and gas may exist in this part of the State. The structure of this area has never been carefully worked out and until that has been done one cannot, with any degree of certainty, express an opinion as to the probable occurrence of petroleum and gas. The reconnaissance work by the early geologists, published in the reports of 1872 and 1873, gives very meager information as to the folding and flexuring of the beds, although folds were recognized and incidentally referred to.

In 1903 the Welle-Boettles Bakery Company of St. Louis struck natural gas in a well which they drilled at their plant on Vandeventer avenue and Forest Park boulevard. The gas was struck at a depth of 670 feet and is reported to have furnished a pressure of 250 pounds. Since then two additional wells have been sunk, from one of which gas was obtained. The second well was sunk to a depth of 1,000 feet without encountering anything but salt water. In the third well traces of oil were found at a depth of 280 feet and gas at 675 feet.

The gas from the first well has been used to heat three furnaces, or six ovens, day and night.

There is very little probability of encountering either gas or petroleum in large amounts in the small basin of Carboniferous rocks, upon which St. Louis is located. Other wells of small pressure may be found but the structure of the region combined with the restricted nature of the basin argues against finding either petroleum or gas in large quantities.

The value of petroleum and gas production in 1903 has been estimated at about $11,000.

PORTLAND CEMENT.

During 1903 two companies have been manufacturing Portland cement in this State, viz.: the Atlas Cement Company, at Hannibal, and the St. Louis Portland Cement Company at Prospect Hill, just north of

St. Louis. The Atlas plant when completed will have a capacity of 7,000 barrels per day while the plant of the St. Louis company has a capacity of 1,500 barrels per day. A third plant is in process of construction at Louisiana, and when completed will have a capacity of 5,000 barrels per day.

There are almost unlimited possibilities in the manufacture of Portland cement in this State. Raw materials in the shape of limestone and shale occur abundantly in the eastern and western parts. The Burlington, Trenton and, in some places, the Upper Coal Measures, contain very pure limestone, while the Hannibal, Hudson River, Hamilton and Coal Measure formations contain, in many places, high grade shales. Wherever shale and limestone occurring together are of such a composition that one can obtain easily, by mixture, silica, alumina and calcium carbonate in about the proportions of 58% to 64% $CaCO^3$ (lime) 18% to 24% SiO_2 (silica) and 8% to 14% Al_2O_3 (Alumina), Portland cement can be manufactured. However, in order to make the manufacture of Portland cement successful one must also consider the cheapness of suitable fuel, the facilities for transportation and the markets.

The Portland cement manufactured in Missouri, in 1903, was valued at $1,164,834, according to the report of the U. S. Geological Survey on "The Mineral Resources of the United States."

PYRITE.

Attention is called to the market which is being created for sulphuric acid by the erection of the oil refineries at Kansas City and in the Beaumont district. These refineries consume great quantities of sulphuric acid which must be supplied by nearby plants. The sulphuric derived from the decomposition of the sulphide minerals is also in demand for the manufacture of sulphuric acid used in the manufacture of fertilizers.

The sulphur dioxide required for the manufacture of sulphuric acid is contained in any sulphide mineral,—blende, galena and pyrite being the most common sources.

Some method should be devised by which the 24 per cent of sulphur thrown into the air during the process of roasting and smelting the lead ores in this State, could be converted into sulphuric acid. In St. Francois county alone, it is estimated that 62,000 short tons of sulphur are expelled from the furnaces each year. This quantity of sulphur would make about 240,000 tons of sulphuric acid.

There are deposits of pyrite or marcasite (iron sulphide) associated with the iron banks which are scattered over the Ozark table-land but many of them are too far from the railroads to be of commercial value.

Associated with the lead ores in Washington and neighboring counties there are considerable quantities of marcasite, which, except for want of transportation facilities, would be valuable for the manufacture of sulphuric acid.

A good grade of iron sulphide, either pyrite or marcasite, is worth \$5.00 a ton.

TRIPOLI.

The output of tripoli in Missouri comes chiefly from Seneca, Newton county. The deposits at this place are very large and exceptionally pure. There are three companies operating in this field, the product being used in the manufacture of filters, as an abrasive and in the manufacture of polishing paste and dynamite. The output in 1903 was valued at approximately \$90,000.

The tripoli at this place is a decomposed chert or flint of Mississippian age. The deposits vary in thickness from 2 to 20 feet.

FINANCIAL STATEMENT

Showing the Expenditures of the Bureau of Geology and Mines January 1, 1903, to December 31, 1904.

(Furnished by the State Auditor.)

1903.

Date.	To Whom Paid.	Amount.	
April 21...	D. K. Gregor	$100 00	Provid'd for in defic'ny bill 1903.
	G. A. Fisher	1 10	
	E. R. Buckley	945 28	
	H. A. Buehler	199 54	
	A. F. Smith	128 60	
	Jesse Parker	54 00	
	Lena Strobach	75 00	
	A. S. Whitehead	24 00	
	H. F. Jóhnson	17 50	
	H. H. Gregg	22 00	
	E. M. Shepherd	58 60	
22...	E. Long	50 00	
May 7....	E. R. Buckley	341 96	
	A. F. Smith	100 00	
	Lena Strobach	35 00	
	Jesse Parker	18 00	
	A. Heinberger	25 25	
	H. T. Jóhnson	7 25	
May 12....	H. A. Buehler	100 00	
27....	E. B. Craighead	17 20	
	E. M. Shepherd	54 20	
June 4.....	E. R. Buckley	354 70	
	Lena Strobach	35 00	
	A. F. Smith	222 08	
	H. A. Buehler	120 25	
	H. A. Rossler	7 00	
9.....	Tribune Printing Company	51 06	
12....	Jesse Parker	18 00	
	H. H. Gregg	19 00	
July 6....	E. R. Buckley	320 02	
	Lena Strobach	35 00	
	Jesse Parker	18 00	
	H. A. Buehler	100 00	
	F. B. Van Horn	90 95	
	E. B. Hall	16 50	

1908—Continued.

Date.	To Whom Paid.	Amount.
Dec. 5....	A. F. Smith	$110 61
	F. M. Harper	21 00
13....	Bicklel Marble and Granite Company	97 20
22....	W. D. Jones	55 00
Aug. 4....	H. A. Buehler	$100 00
	Lena Strobach	35 00
	F. W. Harper	21 00
	Jesse Parker	18 00
	E. R. Buckley	319 21
	E. B. Hall	65 93
	A. F. Smith	152 60
	F. B. Van Horn	159 75
14....	E. B. Craighead	24 10
24....	H. H. Gregg	10 00
Sept. 3....	Lena Strobach	35 00
	H. A. Buehler	100 00
	E. R. Buckley	322 11
	A. F. Smith	165 82
	F. W. Harper	21 00
	Jesse Parker	11 00
8....	F. B. Van Horn	142 00
	E. B. Hall	35 00
Oct. 3....	E. R. Buckley	276 07
	A. F. Smith	157 85
	F. B. Van Horn	153 97
	C. F. Marbut	147 20
	H. A. Buehler	106 55
	E. B. Hall	58 50
	Otto Vaetch	39 55
	Lena Strobach	35 00
	Jesse Parker	21 00
	D. F. Higgins	11 50
	F. W. Harper	7 00
30....	Otto Vaetch	25 50
Nov. 3....	E. R. Buckley	286 70
	H. A. Buehler	116 55
	E. B. Hall	43 40
	Lena Strobach	35 00
	Jesse Parker	21 00
4....	A. F. Smith	153 37
7...	F. B. Van Horn	124 10
19....	D. C. Hardy	33 00

1903—Continued—.

Date.	To whom paid.	Amount	
Dec. 5....	E. R. Buckley	354 34	
	H. A. Buehler	164 56	
	Jesse Parker	21 00	
	F. B. Van Horn	60 00	
	A. F. Smith	162 60	
	Lena Strobach	35 00	
	Mound City Eng. Co	164 18	
8....	E. B. Craighead	7 55	
9....	Library Bureau	55 00	
	H. H. Gregg	19 50	
11....	E. M. Shepherd	30 15	
	Total	....	$8,730 06

1904.

Date.	To whom paid.	Amount	
Jan. 8....	Tribune Printing Co	$13 60	
Jan. 9....	E. R. Buckley	337 56	
	A. F. Smith	151 30	
	Jesse Parker	21 00	
	F. B. Van Horn	60 00	
	H. A. Buehler	112 15	
	Lena Strobach	35 00	
	W. J. Lloyd	154 71	
Jan. 11....	E. B. Craighead	13 10	
Feb. 5....	E. R. Buckley	125 00	
	Lena Strobach	35 00	
	S. C. Brickley	21 00	
	A. F. Smith	151 60	
	D. F. Higgins	5 50	
	F. B. Van Horn	60 00	
Feb. 11....	H. A. Buehler	100 00	
18....	H. A. Buehler	27 93	
Mch. 3....	E. R. Buckley	272 35	
	Lena Strobach	35 00	
	H. A. Buehler	151 85	
	S. C. Brickley	21 00	
	F. B. Van Horn	60 00	
	L. G. Lehman	24 20	

1904—Continued.

Date.	To whom paid.	Amount
Mch. 4....	A. F. Smith	148 25
14....	Oscar Andreen	28 00
16....	Tribune Printing Co.	605 04
17....	E. B. Craighead	15 65
	H. H. Gregg	46 65
April 2....	E. R. Buckley	308 78
	S. O. Brickley	21 00
	Lena Strobach	35 00
	H. A. Buehler	100 00
	L. G. Lehman	12 00
	F. B. Van Horn	36 75
	A. T. Smith	136 35
8....	E. B. Craighead	20 60
12....	E. M. Shepherd	42 25
19....	Mound City Engraving Co.	480 00
27....	Tribune Printing Co.	8 56
May 3....	E. R. Buckley	379 61
	H. A. Buehler	154 49
	A. F. Smith	142 95
	F. B. Van Horn	71 25
	L. G. Lehman	8 92
	Lena Strobach	35 00
	S. O. Brickley	21 00
June 13....	E. R. Buckley	333 15
	H. A. Buehler	20 90
	A. F. Smith	149 75
	L. F. Putnam	16 25
	Lena Strobach	35 00
	F. B. Van Horn	60 00
	S. O. Brickley	21 00
17....	H. A. Buehler	100 00
July 6....	E. R. Buckley	322 70
	F. B. Van Horn	83 30
	A. F. Smith	151 29
	Lena Strobach	35 00
Aug. 4....	Mound City Engraving Co	281 90
	H. A. Buehrle	100 00
	F. B. Van Horn	63 25
	Lena Strobach	35 00
	Ralph Bailey	14 00
	A. F. Smith	145 96

1904—Continued.

Date.	To whom paid.	Amount	
	E. R. Buckley	302 79	
9....	E. B. Craighead	25 80	
16....	Oscar Andreen	270 00	
Sept. 3....	E. B. Craighead	11 75	
	Ralph Bailey	14 00	
	E. R. Buckley	255 40	
	Lena Strobach	35 00	
	H. A. Buehler	100 00	
	A. F. Smith	152 55	
	F. B. Van Horn	60 00	
13....	H. H. Gregg	18 10	
29....	Tribune Printing Co	1,247 53	
Oct. 7....	H. A. Buehler	100 00	
	Ralph Bailey	14 00	
	E. R. Buckley	260 00	
	Lena Strobach	35 00	
	F. B. Van Horn	60 00	
	Aug. Gast Bank Note Co	127 00	
	A. F. Smith	100 00	
10....	E. R. Buckley	82 51	
18....	Aug. Gast Bank Note Co	381 50	
Nov. 7....	E. R. Buckley	358 79	
	H. A. Buehler	100 00	
	F. B. Van Horn	4 00	
	A. F. Smith	100 00	
	Lena Strobach	35 00	
	Ralph Bailey	14 00	
Dec. 2....	E. R. Buckley	250 00	
	Lena Strobach	35 00	
9....	E. R. Buckley	7 89	
	Total		$11,371 04

1907

MISSOURI BUREAU OF GEOLOGY AND MINES.

ERNEST ROBERTSON BUCKLEY, Ph. D., Director and State Geologist

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BOARD OF GEOLOGY AND MINES

TO THE

Forty-Fourth General Assembly

THE HUGH STEPHENS PRINTING COMPANY,
JEFFERSON CITY, MO.

MISSOURI BUREAU OF GEOLOGY AND MINES.

ERNEST ROBERTSON BUCKLEY, Ph. D., Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BOARD OF GEOLOGY AND MINES

TO THE

Forty-Fourth General Assembly

THE HUGH STEPHENS PRINTING COMPANY,
JEFFERSON CITY, MO.

BOARD OF MANAGERS.

His Excellency, Joseph W. Folk, Governor of Missouri, Ex-officio President of the Board..........Jefferson City
Hon. Elias S. Gatch, Vice-President..........St. Louis
Hon. Stonewall Pritchett, Secretary..........Webb City
Prof. Edward M. Shepard, Sc. D..........Springfield
Hon. L. F. Cottey..........Edina

PREFATORY LETTER.

Bureau of Geology and Mines,
Rolla, Mo., Dec. 31, 1906.

To the President, Governor Joseph W. Folk, and the Honorable Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to submit herewith a report on the work of the Bureau of Geology and Mines for the years 1905 and 1906, as required by law. This report contains, first, a review of the work of the Bureau for the biennial period; second, a statement of the expenditures of the Bureau; third, a statement of the needs of the Bureau with recommendations for its increased efficiency; fourth, a summary of mining developments during the biennial period.

The importance of the investigations of this Bureau cannot be estimated from the brief summary contained in these pages. They express very inadequately the influence which this department exerts on the industrial development of the commonwealth. Our investigations reach, not only lead, zinc and coal mining, but also quarrying, cement manufacturing, the exploitation of sand and gravel, materials used in highway improvements, the manufacture of cement, the manufacture of lime, and many other fields. Our reports are sent to all parts of the globe, and through this distribution the mineral resources of the state are becoming more widely and better know.

Whatever of success may have attended our work, is in a large measure, the result of the interest which you, the members of the Board of Managers, have taken in the Bureau. The citizens of the State have, uniformly, welcomed our presence in their midst and through their kindly appreciation of our services we cannot but anticipate an increasing usefulness for the Bureau in the future.

Your obedient sir,

E. R. BUCKLEY,
Director and State Geologist.

STAFF OF THE BUREAU OF GEOLOGY AND MINES.

Ernest Robertson Buckley, Ph. D.	Director and State Geologist
Henry A. Buehler, B. S.	Assistant State Geologist
Guy W. Crane	Assistant Geologist
Miss Lena J. Strobach	Clerk and Stenographer

In addition to the above there have been several temporary employes, none for a longer period than six months. Among these were Messrs. R. H. DeWaters and B. J. Snyder, who assisted in the chemical laboratory; and Messrs. C. C. Baker and F. Grant Cooke, who have assisted in the drafting.

TABLE OF CONTENTS.

CHAPTER I.

EMPLOYES, EQUIPMENT AND PUBLICATIONS OF THE BUREAU.

During the past biennial period there have been few changes in the staff. Our appropriation has not been sufficient to increase the number of employes, as a result of which the requests for our services, in some parts of the State, have been answered only by correspondence. It has been our purpose to carry the investigations of the mineral resources into all sections of the State, irrespective of their present importance, and should any portion seem to have been neglected, it may be attribued to the small number of employes which it is possible to support with the present appropriation.

In the employment of assistants it has been our purpose to select men who have had experience and whose training has been such as to especially fit them for the investigations required by this department. This Bureau is not a training school for students, and its value and efficiency must depend upon the employment of those who are able to carry on original investigations without the constant supervision of the Director.

Your attention is also called to the importance of continuous service on the part of the employes of a scientific bureau of this character. The value of the services of an employe in this Bureau increases with his knowledge of the geology of the State. The first year or two he becomes familiar with geological conditions in the State and may develop into a valuable assistant. If he does not he should be removed. If he does he should have his salary increased in a degree commensurate with the value of his services. This Bureau has not been able to increase the salaries of the assistants in a degree commensurate with their services, and therefore we have lost to other better endowed surveys men who have been trained in our service.

It is only possible to keep such well trained men as are interested, to such a degree, in scientific investigations, that the more remunerative employment with large mining companies does not

serve as an unbalancing attraction. Geological surveys are suffering today from the necessity of employing men who have insufficient training, owing to the fact that there is a greater demand for trained geologists, on the part of the mining companies, than he market will supply. During the last two years even the United States Geological Survey has lost some of its best trained economic geologists as a result of this demand.

During the last year there have been three men constantly employed on the staff of this Bureau. The correspondence, examination of specimens and supervision of the chemical and drafting work requires the presence of at least one person in the office all the time. However, there have been weeks during the year when there was no one in the office except the clerk.

As a rule the Director has given his personal attention to all correspondence except that pertaining to the special investigations in charge of the assistants. Mr. Buehler supervises all chemical work, checking the results and outlining the mehtods to be employed. Mr. Crane has in charge the work in the drafting room, which includes the preparation of illustrations for the various reports.

PUBLICATIONS.

Since the publication of the last biennial report we have published two special volumes and have five others in manuscript form, which will be published during the next year. The volumes that have been published are "The Geology of Moniteau County," and "The Geology of the Granby Area." The first is one of a series of county reports begun four years ago. The second is an economic report containing a discussion of the lead and zinc deposits of an area in Newton county. Both of these reports have been eagerly sought by parties interested in mining. Men interested in mining in the lead and zinc fields of Southwestern Missouri have been especially interested in the report on "The Granby Area," which in its discussion of the origin of the lead and zinc ores furnishes suggestions which should be helpful to all prospectors.

The reports which are in manuscript form are as follows: "The Geology of Morgan County," "The Lime and Cement Resources," "Materials for and Methods of Highway Construction," "The Geology of the St. Francois County Lead District," and "General Geology of Missouri."

The report on "The Geology of Morgan County" was promised for publication two years ago. Professor C. F. Marbut, the

author, has been delayed in the completion of this report by duties connected with the University. The management of this Bureau is in no way responsible for the delay. The finished manuscript is in our hands, corrected up to date, and it probably has not suffered any from the lateness of its completion.

The report on "The Lime and Cement Resources," by Mr. H. A. Buehler, is also in manuscript form. The preparation of this report has required a great deal of field work and Mr. Buehler has visited ever county in which it was thought that materials suitable for the manufacture of Portland cement might exist. Specimens have been collected and analyzed, outcrops have been examined, and economic conditions studied so that we may be able to answer intelligently any inquiries that may be made as to the suitability of certain localities for the manufacture of cement.

The results of these investigations seem to indicate that Missouri contains, in a number of undeveloped places, limestone and shale well adapted to the manufacture of Portland cement. At least, this report will indicate areas which warrant further detailed exploration.

There are now two Portland cement factories in operation and two more in process of construction in this State. Were all the areas, where suitable limestone and shale for the manufacture of Portland cement occur, provided with adequate transportation facilities, this State might supply the entire Mississippi Valley with cement. With the transportation facilitles whch we now have, we predict an enormous expansion of the Portland cement manufacturing industry in the near future.

This State is abundantly supplied with limestone, suitable for the manufacture of quicklime. However, for many uses, the lime is being supplanted with cement, which leads to the belief that there will be, in the country at large, less activity in the quicklime business in the near future. The introduction of processes of hydration and the use of quicklime as a fertilizer may stimulate the industry to such an extent as to more than offset the use of cement.

The price of Portland cement is, at present, very high, when one considers the cost of manufacturing, which should not exceed eighty cents per barrel.

The report on "The Material for and Methods of Highway Construction," by the Director of the Bureau, has been prepared during the last six months at the direction of the Board of Managers. In collecting the information bearing upon the condition of the roads I have had the co-operation of the rural free delivery

carriers through the direction of the United States Postoffice Department. Photographs have been secured showing the character of the improved and unimproved highways; and drawings are being made illustrating the latest methods of improving the highways. Each of the different kinds of pavement in use in the cities is discussed and full specifications for construction are given. Sidewalk, curb and gutter constructions are also considered in this manner.

The chapter on "Materials Available" brings out the necessity for a State testing laboratory, where comparative tests of stone, cement, brick and pipe may be made without cost to the town or village submitting the materials for examination.

The chapter on "Methods of Construction" brings out the need for carefully executed topographic maps, such as are being prepared by the U. S. Geological Survey. The preparation of maps showing the hills, valleys, streams, buildings, roads, marshes, etc., should precede the systematic, permanent improvement of highways by the State.

The report on "The Geology of the St. Francois County Disseminated Lead District," by the Director, has been in preparation for some time and would have been published before now had it not been for the additional reports which he has been called upon to prepare. The field work for this report has been finished, the maps are being engraved and the manuscript will soon be ready for the publishers.

The report covers the geology of one of the most important lead-producing districts in the United States. The origin of the lead has been very obscure and few persons have been able to offer any tangable reason for the position of the ore bodies. The study of the physical conditions existing in this district has been an extremely slow and sometimes tedious process. Close application and persistent work, however, have furnished us with data which it is thought give the basis for a reasonable hypothesis of the origin of the ores. Such being the case, an application of the theory ought to assist very greatly those who are engaged in prospecting for new or exploiting old ore bodies.

These investigations have resulted in limiting the area of profitable prospecting for bodies of disseminated ore, on at least three sides, and by pointing out the structural and other conditions within the mineralized area, should assist very greatly in the location of new ore bodies.

The report on "The General Geology of Missouri" is intended

as a manual for those interested in geology or mining; but it is so arranged that it will serve as a useful reference book for teachers of physical geography in the public schools of Missouri.

This volume has been written in response to a wide-spread demand among prospectors and miners for a "book" containing the rudiments of geology. In this volume the common minerals and rocks are named and described, and simple methods of identifying them are given; the common structures in rocks are described and their origin considered; the geologic agents, through which changes upon the surface of the earth are brought about, are discussed; and there is a chapter devoted to the geological history of Missouri. The second part of this volume is devoted to a discussion of the mineral, stone, clay and other similar resources of Missouri. This is accompanied by maps of the State showing the location and distribution of all mines, quarries, clay-working plants, cement factories and limekilns. There are also geologic and relief maps, and maps showing the production by counties of the more important mineral resources, including lead, zinc, coal, barite, iron, stone, cement, quicklime, and clay products.

The statistics upon which the maps showing production are based are necessarily incomplete, owing to the inattention shown by some producers to our repeated requests for this information.

Of the reports published by this Bureau the following volumes remain for distribution. They are sent out to those desiring them upon receipt of the amount of postage given below:

Preliminary Report on Structural and Economic Geology, Vol. XIII, 1900, by John A. Gallaher	2,950
New Year's Announcement, January 1, 1901, by John A. Gallaher	423
Biennial Report of the State Geologist to the 41st General Assembly by Leo Gallaher	356
Areal Geology, Vol. XII, Part II., by C. F. Marbut and G. C. Broadhead	159
Biennial Report of the State Geologist to the 39th General Assembly, by Charles R. Keyes	143
Geology of Miller County, Vol. I, 2nd Series, 1903, E. R. Buckley, A. F. Smith and S. H. Ball	1,103
The Quarrying Industry of Missouri, Vol. II, 2nd Series, 1904, by E. R. Buckley and H. A. Buehler	1,971
Biennial Report of the State Geologist to the 42nd General Assembly, by E. R. Buckley	285
The Geology of Moniteau County, Vol. III, 2nd Series, 1905, by F. B. Van Horn	1,337
Biennial Report of the State Geologist to the 43rd General Assembly, By E. R. Buckley	748
Geology of the Granby Area, Vol. IV, 2nd Series, 1906, by E. R. Buckley and H. A. Buehler	2,675

These reports are distributed upon application, provided the request is accompanied with stamps to cover cost of mailing, as follows:

Vol. XIII, 25c.; Vol. XII, Pt. 2, 25c.; Vol. I, 2nd Series, 25c.; Vol. II, 2nd Series, 40c.; Vol. III, 2nd Series, 15c.; Vol. IV, 2nd Series, 20c.; all others, 10c.

TOPOGRAPHIC MAPS.

This State has never made an appropriation for topographic mapping in co-operation with the United States Geological Survey, although neighboring states are yearly taking advantage of the co-operative plan to secure maps which are of inestimable value to all who are interested in internal improvements, such as highways, drainage, irrigation, etc. In spite of this apparent lack of interest, we have succeeded, through the friendly relations existing between the United State Geological Survey and this Bureau, in securing the preparation of one or more topographic sheets each year.

The making of topographic maps should always precede a study of the geology, and in having the Forsythe sheet, comprising parts of Ozark and Taney counties, mapped, we have planned to study the geology of that area. During the last two years sheets comprising an area of 1500 square miles have been mapped topographically.

EQUIPMENT.

The equipment of the Bureau may be said to consist of a library of about four thousand volumes of reports and pamphlets; six thousand specimens of minerals, ores, rocks and fossils; and miscellaneous instruments required for field work.

The library consists almost exclusively of reports of home and foreign geological surveys; transactions and proceedings of scientific societies; technical journals; and reports of departments or bureaus of mines and mining. These volumes have cost nothing except the transportation charges on our own reports which have been sent in exchange. By means of exchanges we have been gradually adding to the library such reports as we believe will be valuable for reference in prosecuting the investigations being carried on by this Bureau. There are many volumes on geology and mining published each year, but for the purchase of which we have never devoted any of our appropriation. Sometime, in order to make the library what it should be, these volumes should be purchased. There are in the library several hundred volumes of transactions of scientific societies and technical journals which should be bound, but for which funds have not been available.

The Specimens which are in the museum have not been collected with a view to their exhibition qualities, but chiefly to illustrate the usual characteristics of the rocks, ores and minerals

of the State. The collection of lead and zinc ores is being added to each year and with some attention it will soon be among the most valuable in the country. During the past two years over two hundred spcimens have been added to this collection. Additions have also been made to the collections of rocks, fossils, barite ores, clays, etc. Owing to a lack of exhibit cases a considerable portion of this collection is packed in boxes. There is in this collection the nucleus of what might be made a magnificent representation of the mineral, clay and stone resources of the State.

The *equipment of the Bureau* includes chiefly compasses, levels, transit, aneroid barometers, tape lines, hammers, balances, drafting instruments, office furniture, filing cabinets, typewriter, etc.

Most of the equipment, including the furniture, has been in the Bureau for years and should be replaced by new. The most efficient service can only be rendered by those who have at their command the best tools with which to work.

The Bureau does not have the necessary machinery, instruments or furnaces for testing stone, clay and other materials which may be valuable for cement, brick, tile, etc. There is no machinery for testing cement, tile, brick and other materials used in the construction of buildings, highways, etc. These will be considered in another chapter in which the needs of the Bureau are discussed.

CHAPTER II.

A REVIEW OF THE WORK OF THE BUREAU FOR 1905 AND 1906.

The work of the Bureau may be separated into two general classes: (1) That which is conducted for the purpose of publishing special areal, county or general reports, and (2) office and laboratory investigations to supply to individuals information relative to the mineral resources of the State.

The work of this Bureau can best be summarized in the following paragraphs taken from our report to the "Forty-third General Assembly":

1st. To ascertain the relations existing between the different rock formations at or near the surface of the earth and prepare county reports containing maps, drawings and other illustrations setting forth these facts and giving the thickness, surface distribution, structure and characteristics of each formation.

2nd. To examine the metallic and non-metallic mineral resources, including stone, clay, cement, road materials, soils, water, lead, zinc, iron, coal, petroleum, asphalt, copper, barite, sand, etc., publishing complete reports outlining their distribution and describing their manner of occurrence.

3rd. To collect, name and arrange a collection of specimens illustrating the geology and mineral resources of the State; also to assist the colleges and schools in the making of similar collections.

4th. To examine ores, rocks, soils, clays, and other mineral specimens for citizens of the State, reporting as to the kind and value of any specimen submitted for examination.

5th. To disseminate, everywhere, correct ideas as to the occurrence, origin, and relation of ores, minerals and rocks, for the purpose of increasing the general intelligence of the public on matters pertaining to geology and mining.

6th. To answer all inquiries relative to the mineral resources of the State.

7th. To examine, upon petition of fifty freeholders, lands upon which ores, clays, stone or other mineral resources of value may be thought to exist.

8th. To co-operate with the United State Geological Survey and other bureaus of the United States Government where benefit will accrue to the State.

The ultimate purpose of this work is to aid in the the development of the mineral resources (metallic and non-metallic)—1st, by preparing maps, charts and reports, which will assist the prospector in carrying on his work with greater accuracy and a higher degree of intelligence; 2nd, by calling the attention of the public to undeveloped and partly developed resources; 3rd, by examining and reporting on specimens submitted by citizens of the State to this department; 4th, by increasing the general intelligence of the public through sending out to colleges and public schools mineralogical collections and published reports and addressing mining clubs and other organizations; 5th, by answering inquiries relating to the mineral resources of the State.

Under the first of these duties it may be said that we have practically established the succession of formations in the Ozark region, through field work in the southeastern and southwestern portions of the State. To accomplish this the formations have been mapped over special areas and sections have been made across various portions of the country for which geological maps have not been made. The structures along the lines of these sections have been observed and their effect on the changes in the surface geology have been determined. These results will be embodied in maps and drawings to be inserted in the forthcoming report on the "General Geology of Missouri." An attempt has also been made to correct the boundary lines between the various formations, so that subsequent editions of the geological map may delineate them more accurately.

The second of the duties enumerated above has consumed a large part of the time of myself and assistants. For several years we have had under investigation the disseminated lead district of St. Francois county. The problems connected with the occurrence of the ore bodies of that district have been extremely difficult to solve. The operators have been prospecting the region with little or no idea of the relations which the ore bodies sustain to the structure and stratigraphy. They have had very vague ideas as to the probable limits of the productive area.

We believe that the origin of these ores has been determined; that the relations between the ore bodies and the structures have been worked out; and that the limits of the productive area have been fairly well established on three sides. The determination

of these facts should be of great value to the State by directing prospecting into those areas which offer some hope of containing bodies of disseminated ore.

Our investigations in the southwestern lead and zinc district, which are, in part, contained in the report on "The Geology of the Granby Area," brought out facts, bearing on the relation of the ore bodies to the country rock, which should be very helpful to the prospector. Although our investigations in that district have not determined the probable limits of the producing area, we are confident that there is an extensive territory in this part of the State which should receive the attention of those interested in mining.

The report on the Granby area gives a full discussion of the origin of the lead and zinc minerals and the relations of the various structural features and formations to the ore bodies. The forthcoming report on the General Geology of Missouri will contain maps showing the area underlain by the ore-bearing formation and the location of the mines now in operation. Our investigations begun in the Granby Area should be continued over the entire district in order to fully supply the information most helpful to the prospector.

The constantly increasing demand for Portland cement in this country has led to an active demand for information concerning the location of limestone and shale deposits suitable for the manufacture of this material. For more than a year we have been carrying on an investigation of the limestone and shale deposits in all parts of the State. The results of this investigation, when published, will show that there is an abundant opportunity for the manufacture of Portland cement in a great number of localities, especially in the northern and eastern parts of the State. In conducting this investigation, we have examined deposits of shale and limestone in the field and made determinations of their probable extent. Observations have also been made relative to the probable cost of exploitation and the nearness of the locality to an adequate supply of fuel. Analyses have been made of the limestones and shales and from these we have been able, in a measure, to determine the fitness of the materials for the manufacture of Portland cement. Chemical analyses are, of course, not final, it being extremely important that actual burning tests be made. The Bureau, however, is not equipped with the necessary facilities for these experiments. Although the results of our investigations are not final, they are sufficient to indicate localities which offer promise of successful exploitation to those who desire to manufacture Portland cement.

In connection with the investigation of the Portland cement resources, we have made an examination of the limestones to determine their suitability for the manufacture of quicklime. Although it is true that quicklime is, in a measure, being supplanted by cement, nevertheless, it will be many years before the demand for quicklime will be materially decreased. Through these investigations we are able to state that there are numerous undeveloped localities possessing limestone suitable for the production of quicklime.

It is evident from our investigations that the railroads, through discrimination in rates, control the location of lime plants along their lines. The large producers apparently have an advantage over the smaller ones. However, in the face of this it has been extremely difficult during the last months of 1906, for even the large plants to secure cars to move their product and thus fill the orders already booked.

The demand for information on materials for highway construction has led us to investigate the character of the materials available for highway improvement in Missouri. These investigations have not included tests of stone, but have been confined chiefly to an examination of the highways and the materials in close proximity which might be used for their improvement. We have also conducted an investigation of the condition of the highways throughout the State. The results of all of these investigations will be published in a volume on Highway Construction, to which the reader is referred.

Although we have not taken up the systematic investigation of any of the other mineral resources of this State, we have been called upon to make reports upon lands thought to contain valuable deposits of coal, iron, petroleum, barite, etc. It appears quite essential that this Department should take up an investigation of the petroleum and gas resources in the northwestern part of this State and the barite in the southeastern part.

The third duty with which this Bureau is charged has been constantly in our mind. We have been collecting, naming and arranging specimens, illustrating the geology and mineral resources of this State whenever opportunity presented itself. It has not been possible to collect the specimens in sufficient abundance to distribute to colleges and schools in the State. We have had very little, if any call, for mineral collections, but it is known that the teachers in our public schools are desirous of securing such spec-

imens as may be available. This Bureau would perform a very valuable educational service to the children in Missouri, if this Bureau could be provided with funds for the making of collections to be used in the schools and colleges of the State.

The fourth duty with which this Bureau is charged has been fully carried out. We have received many specimens of ores, rocks, clays and minerals from citizens of this State, all of which have been examined and reported upon by this Bureau. In some cases, where it was thought that the conditions warranted, chemical analyses have been made. In most cases, however, the specimens were merely identified and their value reported upon. The examination of specimens consumes considerable time, requiring a part of the time of one of the assistants throughout the year.

The fifth duty with which the Bureau is charged, we believe, has been faithfully performed. Whenever an opportunity has presented itself, we have sought to explain the origin, manner of occurrence and relation of ores, minerals and rocks to those interested. In some instances we have addressed commercial clubs and other public organizations relative to the geology and mineral resources of their immediate locality. Geology and mining appear to be two of the branches in which the public has had little or no instruction. For this reason some difficulty is met in explaining intelligently the conditions which may be favorable or unfavorable to the occurrence of minerals or ores in any special locality.

The sixth duty, which calls upon the department to answer inquiries relative to mineral resources in the State, has been promptly performed. We receive inquiries concerning the varied resources of Missouri from citizens in different parts of the United States. Some inquiries also come to us from foreign countries. A majority of our correspondence is with citizens of Missouri.

The examination of lands upon which ores, clays, stone or other mineral resources of value are thought to exist, upon petition of fifty freeholders, has been fully carried out. All petitions of this character have been answered. The reports, which are made in conformity with this statute, are published in the following chapter.

This Bureau has co-operated constantly with the United States Geological Survey and with other Bureaus of the United States Government. In co-operation with the United States Geological Survey, we have secured the mapping topographically of several areas within the state. Several of the geologists of the United States Survey have spent weeks in the state assisting

in working out some of the more difficult geological problems with which this Bureau has been confronted. We have been assisted in every possible manner by the United States Government in carrying on our work. In most states, there is a definite plan of co-operation, but in this State we have been unable to enter into a co-operative arrangement on account of a lack of a specific appropriation for this purpose.

CHAPTER III.

REPORTS SUBMITTED IN ANSWER TO PETITIONS.

In 1901 the Legislature passed a law directing the State Geologist to examine and report upon lands in any county in this State, upon presentation of a petition signed by not less than fifty freeholders residing in the neighborhood of said lands, which may be thought to contain valuable ore or upon which they have found valuable "ore, clays, rocks, coals, minerals, oils or mineral matter," said petition to be certified to by the clerk of the county court in which the petitioners reside.

Since the passage of this law no specific appropriation has been made to carry out its provisions. Occasional petitions have been received, and each has been answered in person, either by the State Geologist or his assistant, the expenses being met out of the general appropriation for the Bureau.

The law does not require that the results of the examinations be published in the biennial report, but rather in the final reports. It is believed, however, that the interests of the citizens are better conserved by publishing the results of these investigations in the biennial reports.

The following are copies of the reports made during the last two years, in answer to petitions:

REPORT ON QUARRY NEAR ROCHEPORT.

Mr. C. H. Carter, Liberal, Mo.:

Dear Sir—On June 29, 1905, I made an examination of the stone outcropping in the N. ½ of Sec. 17, T. 48, N., R. 14 W., for the purpose of determining its suitability for the development of a quarry to furnish stone for buildings and other constructions. Accompanying this report is a section showing the succession of beds with a brief description of each.

12-15 ft.	Beds not opened. Apparently rather thinly bedded, although they will probably become solid when worked into the hill. Flint nodules probably occur, although their presence could not be detected owing to soil. Color and texture similar to lower portion of section.
6 in.	White Flint.

5 ft.	Gray, coarsely crystalline limestone in beds from 6 to 18 inches thick. Large suture joint 2 ½ feet from bottom.
6 in.	White Flint.
5 ft. 6 in.	Coarsely crystalline, bluish gray limestone. Very fossiliferous. Flint noted 3 feet from bottom, probably a layer at this point. Suture joints from 6 to 12 inches apart.
6 in.	White Flint Nodules.
2 ft.	Fossiliferous, coarsely crystalline, gray limestone.
6 in.	White Flint.
3 ft.	Medium to coarsely crystalline limestone showing occassional flint nodules 1 foot from base. Suture joints.
1 ft. 8 in.	Layers of flint and gray limestone.
2 ft. 9. in.	Coarsely Crystalline, homogenous bed of gray limestone. Suture joints occur from 4 to 6 inches apart.
1 ft.	Round nodules of flint
1 ft. 4 in.	Coarsely textured, gray limestone.
3 ft.	Thin beds of limestone from 4 to 6 inches in thickness with interbedded layers of white flint.
1 ft. 6 in.	Gray, fossiliferous limestone.
6 in.	White Flint.
12 ft.	Gray to brown, fossiliferous limestone. Changes somewhat in texture being very crystalline and very fossiliferous. Free from flint except 4 feet from top where one or two nodules were noted. Suture joints from ½ to 2 inches in thickness occur from 2 to 10 inches apart. Ledge will work solid.
6 in.	White Flint.
3 ft.	Coarsely crystalline, very fossiliferous limestone. Shows large 3 inch suture joint in center of bed.
10-12 ft.	Slope.

This section shows a variable (1-15 ft.) thickness of lœss (clay) overlying the stone. Underneath this lœss there are 12 to 15 feet of limestone, which was so poorly exposed that I was unable to determine the quantity of flint which it contains. In texture and color it does not vary materially from that underneath. From this bed to the base of the hill beds of limestone alternate with layers of flint nodules, as shown in the section. Near the top there are two beds of limestone, 5 feet and 5 feet 6 inches in thickness, separated by layers of flint nodules, which could be quarried economically. They are medium textured and have a grayish color.

Seventeen feet of the section below these beds consists of alternating thin beds of limestone and flint nodules. Unless these beds can be utilized in crushing and in lime kiln plants it will not be practicable to work the quarry to a greater depth. If these seventeen feet can be disposed of in such a manner as to pay the expense of removal, a 12-foot ledge, which lies underneath, will furnish a good grade of building stone.

In general, there are three ledges of stone which will furnish mill blocks for building purposes. These may be channelled. The remainder of the quarry contains stone which will be waste unless used for burning quicklime or crushed for ballast and concrete work.

It is my belief that a quarry can only be operated at this place, with profit, in conjunction with quicklime and crusher plants to dispose of waste. This would necessitate a considerable investment.

The success of lime and crusher plants will depend upon fuel, transportation and markets, each of which must be investigated before opening up a plant. These I have not looked up.

The stone belongs to the Burlington formation, and is similar to that quarried near Hannibal. It is a very pure limestone, and should make a first-class quicklime.

Respectfully submitted,

H. A. BUEHLER.

REPORT ON PETITION FROM RICH HILL.

Mr. John Klumpp, President Rich Hill Oil and Gas Development Co., Rich Hill, Mo.:

Dear Sir—On July 11, in response to a request of the Board of Directors, I made an examination of the lands under option by the Rich Hill Oil and Gas Development Co., for the purpose of making recommendations relative to a continuation of the drilling now in progress.

During the investigation, three questions arose:

1st. The identity and depth of the Mississippian limestone.

2nd. The probability of finding petroleum or gas below the Mississippian limestone.

3rd. The probability of finding petroleum or gas above the Mississippian limestone.

First—The evidence at hand leads me to believe that the Missisippian limestone occurs at a depth from 250 to 450 feet, depending upon the altitude of the surface of the land, the distance and direction from Rich Hill, and iregularities in the contact surface of the Mississippian limestone with the coal measure strata.

Second—The holes which have been drilled in the western part of Missouri, from Newton county to Livingston county, give no evidence that either petroleum or gas occur within or below the Mississippian limestone. For this reason I cannot recommend drilling through this formation.

Third—Drill holes in the western part of Missouri show that oil and gas occur in the sandstone, and even in the shale (slate) above the Mississippian limestone. Our records, however, indicate that the gas pressure is light, and that the oil is of an asphaltic na-

ture. The conditions for a large supply of gas may exist in the formation above the Mississippian limestone, but up to the present time they have not been discovered. Wherever the sandstone is sufficiently thick and extensive to constitute a storage reservoir, its proximity to the surface admits of the escape of the gas along the lines of outcrop and through fissures. As a result, the quantity of petroleum and gas are usually very limited.

There is evidence of an unusually large body of sandstone crossing the farm of Mr. C. C. McGinnis. It occurs under conditions which are more favorable for the retention of oil and gas than any with which I am acquainted in your immediate vicinity. It is possible that this sandstone may contain a considerable quantity of gas. The present drilling, however, shows a very light pressure, and for this reason the presumption would be against the occurrence of gas in commercial quantity. I am inclined to believe, in spite of this, that there is sufficient encouragement to warrant the company in drilling several additional holes to a depth of not to exceed 350 feet. These holes should be located northwest of where the drill is now stationed. If these holes are barren, I would recommend the abandonment of the project.

Recpectfully submitted,

E. R. BUCKLEY,
State Geologist.

REPORT OF PETITION FROM AVA.

Mr. M. C. Reynolds et al., Ava, Mo.:

Gentlemen—In answer to your petition received July 12, I visited Ava, August 1st, and examined the W. ½ of Sec. 11, T. 26, R. 16, in order to ascertain the probable occurrence of oil and gas upon said section.

The above land occupies an east and west valley just north of Ava, the hills rising gradually on either side. The surface formation consists of dolomitic limestone of Cambro-Ordovician age, covered with residual clay and chert fragments. Nodules and thin layers of iron oxide occur in the clay. Beneath the limestone occurs a sandstone bed which outcrops between Ava and Mansfield, and is said to be exposed along the stream some distance west of Ava. No shale bodies were noted in the region.

What was thought to be an indication of oil consists of a thin irridescent scum covering small stagnant pools, which generally show a reddish sediment of oxide of iron. This scum is due to a

thin film of oxidized iron, brought into the pool, in solution, by seepage. The iron gradually settles to the bottom, causing the red precipitate, which colors the surface of the clay.

Gas occurs in the creek bed northwest of the city, and in a spring some distance up stream. At both places small bubbles of gas rise to the surface of the water at irregular intervals. The gas, occurring in the stream bed is combustible, and has been noted only during the past year. A short distance up stream is a saw mill, which has been in operation for three or four years, and from which sawdust and refuse is dumped into the stream. A portion of this refuse, washed down stream, has undoubtedly lodged in the gravel and clay covering the creek bottom. To the decomposition of this material, which generates combustible gases, is due the gas in the creek bed.

An examination was made of the gas in the spring, and it was found to be non-combustible and odorless. It is undoubtedly air drawn along with the water issuing from the spring.

No geological structures favorable to the storage of oil and gas were noted in the district. The only formation having sufficient openings for the retention of any considerable amount of these materials is the sandstone occurring below the dolomitic limestone. Further there is no impervious layer above this stratum to retain oil and gas were it ever present in the sand. The streams have also cut into it in many places, forming openings along which both oil and gas would escape. This sandstone, which was examined between Ava and Mansfield, shows no indications of having ever been impregnated by oil. The formations are geologically much older than any in which oil and gas have been found.

From the above considerations I do not believe that either oil or gas occur in commercial quantities in the vicinity of Ava.

Respectfully submitted,

H. A. BUEHLER,

Assistant State Geologist.

REPORT ON AN EXAMINATION OF A TRACT OF LAND NORTHEAST OF PARIS, INCLUDING SEC. 36, T. 55, R. 10 W., SEC. 1, T. 54 R. 10 W. PART OF SEC. 6, T. 54, R. 9 W., AND PART OF SEC. 31, T. 55, R. 9 W.

On the 7th of October, in company with Messrs. Frank W. McAllister and J. W. Fouche, I made an examination of the above-described lands. This examination consisted in traversing, on foot,

the principal valleys and ravines, inspecting all the outcrops visible at the surface; and in going into the coal mine in section 1 and studying carefully its position with respect to the formations as observed at the surface.

The limestones belonging to the Mississippian era are below the horizon at which one may expect to find coal. In fact, one who is familiar with the relation which this formation bears to the coal measures, would not expect to even prospect this limestone, either by sinking shafts or drilling into it.

If one is to understand the peculiarities of the manner of occurrence of the coal measures and the coal, he must know the conditions under which they were laid down. These may be easily understood when we picture a land surface in many respects similar to the one we now have. It was not level, but, trenched with streams, and it consisted of hills and valleys.

The Pennsylvanian sea, in which the coal measures strata were deposited, filled the valleys *first*, and often in these depressions, especially near their heads, there accumulated vast quantities of vegitable matter. This was subsequently transformed into coal, forming locally a very thick seam. The presence of these valleys or local depressions are often indicated by the presence of cannel coal. It seems that these depressions were necessary for its formation.

It is in one of these ancient valley deposits that the mine in Sec. 1 is located. The seam in this mine has a thickness of about 6′-8′, of which 5½′ is bituminous and 3′ (not exposed) is cannel coal.

The base of the coal measures at this mine is about 620 feet above sea level, while the prairie land north and west is 720 feet above sea level—a hundred feet higher. As nearly as could be determined, the top of the Mississippian limestone is at an average elevation of 660 feet. This would make the thickness of the Coal Measure strata and overlying soil about 60 feet. Locally in the ancient valleys, as pointed out above, the Coal Measures may be 100 feet thick.

The conclusions reached from the examination may be briefly summarized as follows:

1st. That the seams of coal encountered at a depth below 660 feet above sea level, will not be co-extensive with the prairie land, since they occupy valley-like depressions in the underlying Mississippian limestone. This applies to the seam being exploited in Sec. 1.

2nd. That above an elevation of 660 feet A. T. a seam or seams of coal may occur. These seams are undoubtedly very much thinner than the seams which occur in the depressions referred to above. They will, however, be persistent over a much greater area, underlying probably the entire prairie. Their thickness can only be ascertained by drilling or sinking shafts down to the Mississippian limestone.

3rd. In some places this seam may be removed, as a result of glaciation. This is a factor that we cannot figure on.

4th. The coal, occurring in the depressions, is probably not as desirable as that which may be found by drilling on the prairie.

5th. The pockets of coal occurring in the depressions may be sufficiently large to work, and may afford thousands of tons of coal. It is estimated that a seam of coal five feet thick will produce over six thousand tons of coal to the acre. The area underlain by these pockets can only be determined by sinking shafts or drilling.

6th. I would recommend drilling a number of holes to determine the area of the thick seams and also a number of holes on the prairie to ascertain the thickness and character of the coal which may occur underneath the more elevated tracts of land.

Holes might be drilled to advantage in the N. E. ¼ of Sec. 36, T. 55, R. 10 W.; in the S. W. ¼ of Sec. 1, T. 54, R. 10 W.; and near the middle of the N. W. ¼ of Sec. 36, T. 55, R. 10 W. These holes will probably not need to be over 100 feet deep.

7th. The coal which was examined, on account of its proximity to the surface, was weathered and broken into small pieces with seams. It also contains iron pyrites finely disseminated through it. The quality will probably improve as the seam is worked deeper into the hill.

Respectfully submitted,

E. R. Buckley,

State Geologist.

REPORT ON PETITION FROM GOODMAN.

Mr. D. A. Burch, Goodman, Mo.:

Dear Sir—In response to a petition from yourself and other property holders of McDonald county, I visited and examined certain lands described in said petition, situated along Buffalo creek, and described as follows:

N. E. ¼ S. W. ¼ Sec. 12, T. 23, R. 34 W.; N. E.-N. W. Sec. 13,

T. 23, R. 34; S. E. N. W. and N. E. S. W. Sec. 14, T. 23, R. 34; N. W. S. W. Sec. 26, T. 23, R. 34; S. E.-N. W. Sec. 26, T. 23, R. 34; N. E. S. W. Sec. 27, T. 23, R. 34; N. W. S. E. Sec. 27, T. 23, R. 34; N. E. S. E. Sec. 27, T. 23, R. 34.

I found this section of the county to be underlain chiefly with the Mississippian limestone, which, in certain places, is covered with a varying thickness of shale and sandstone belonging to the Pennsylvanian. The valleys are covered with soil, clay and gravel and everywhere on the ridges and hillsides there is broken flint. On some slopes the flint is more abundant than on others.

On the following described properties I examined the broken rock taken from shafts sunk thereon:

1. N. E. ¼ S. W. ¼ Sec. 13, T. 23, R. 34W.—Shaft 116 ft. deep.
2. N. E. ¼ S. W. ¼ Sec. 14, T. 23, R. 34W.—Shaft 25 to 30 feet deep.
3. N. W. ¼ S. W. ¼ Sec. 26, T. 23, R. 34W.—Shaft 60 feet deep.
4. S. E. ¼ N. W. ¼ Sec. 26, T. 23, R. 34W.—Shaft 16-20 feet deep.
5. N. E. ¼ S. E. ¼ Sec. 27, Shaft 220 feet deep.
6. N. E. ¼ S. W. ¼ Sec. 27, T. 23, R. 34W.—Shaft 25 feet deep.

Shaft No. 1 is almost entirely in Pennsylvanian shale. On the hillside above and on that across the ravine the Mississippian limestone outcrops. Some limestone boulders were encountered near the base. Pyrite is quite abundant in the shale, and where it is exposed at the surface the shale is yellow as a result of the oxidation of the pyrite. Where fresh the shale is blue. With the shale there occurs a thin seam of coal, pitching at a high angle. The limestone outcropping at this place contains no very thick beds of flint.

Shaft No. 2 passed through some shale but chiefly limestone. There is limestone on the hillsides above and below. Some pyrite in the shale.

Shaft No. 3 passed through some shale but is chiefly in limestone. This shaft is near Buffalo creek and limestone occurs on the hillside to the east and above the shale. Some blende was reported from this shaft.

Shaft No. 4 is mainly in limestone. There is nothing to note except perhaps the small percentage of flint and the freshness of the limestone.

Shaft No. 5 is the deepest of any in the area examined. It passed through limestone although on the hillside, northwest of the shaft, there is considerable shale. In the road below the shale outcrop, a thin, knife-blade seam filled with galena was observed. The shaft passed through some limestone carrying zinc blende in cavities. The samples on the dump were not rich enough to indi–

cate a rich ore body, but gave evidence that the underground waters must have carried zinc in solution and that wherever open flint ground occurs there is a probability of finding an ore body.

Shaft No. 6, is shallow but the rock on the dump carries some blende. On the knoll just north there is some sandstone which in places near the base is conglomeritic. A thin veinlet of galena was observed in one of the blocks broken from the surface. There are several other shallow shafts on this land.

In addition to the shafts several holes have been drilled in this area. The cuttings from one of these holes was examined. It consists chiefly of limestone, which indicates that the flint is subordinate in quantity. It is reported that blende was encountered in several of the holes, but the cuttings from these holes were not seen.

In general it is my impression that this limestone, where examined, is too tight in most places to permit the accumulation of zinc blende in quantities sufficient to make ore bodies of commercial size and richness. It appears probable, however, that areas may be discovered where the rock is sufficiently open to admit of the necessary concentration. Prospecting close to the sandstone and shale outcrops, but not through them, is advised. It is also believed that there is a greater probability of locating ore bodies on the table land areas away from the valley, provided the shale outcrops are to be found. Prospecting should be carried on away from the shale areas in the direction in which they dip.

The conditions through which the bodies of lead and zinc ore are formed have been present over this region, but it still remains to be demonstrated, by drilling, whether or not the openings, in which the ore may concentrate, are present.

There is no commercial quantity of coal to be found in the area inspected.

Likewise there is no evidence to warrant one in predicting the discovery of oil or gas. These will probably never be found in this section of Missouri.

Some of the clay near the surface might, if washed, be used as a paint pigment.

There is an abundance of good limestone for building purposes and for the manufacture of quicklime.

Respectfully submitted,

E. R. BUCKLEY,

State Geologist.

CHAPTER IV.

FUTURE WORK AND NEEDS OF THE BUREAU.

Field Work. With the appropriation which has heretofore been available, it has been impossible to carry on the geological investigations desired by citizens in different sections of the state. We can only carry three or four lines of investigation at any one time. If we were to undertake more it would require an undesirably long time to get the reports into print. For this reason we have delayed field work in the northwestern part of the state, where considerable interest is centered around the possibility of securing petroleum or gas. For the same reason detailed investigations of the Ozark-Taney county and other areas have been deferred. With the present appropriation we cannot complete work in any one area before urgent requests for similar work come in from other areas. It is impossible for our Bureau to anywhere near meet the demands made upon it by the mining interests of different sections of the state, in the preparation of detailed geological reports.

During the next biennial period, in addition to the investigations already under way, we wish to begin the preparation first,—of a report on "The Geology of Northwestern Missouri," with special reference to the possible occurrence of petroleum and gas; and second,—of a report covering the "Lead and Zinc Deposits of Southern Missouri," including such areas as may lie outside of the well-known "Joplin" and "Disseminated" districts. The field work for these investigations during the next biennial period will cost at least $15,000, two-thirds of which should be spent in the investigations in northwestern Missouri.

Laboratories. In the preparation of nearly all the reports of this Bureau, there are required chemical analyses of rocks, ores, minerals, clays, etc. In addition to this, the Bureau frequently receives specimens, from citizens, which require an analysis before an intelligent report can be made as to their value. During the summer months, when the School of Mines is not in session, the courtesy of their laboratory has been extended to our chemist.

During the time that the School of Mines is in session the facilities at our disposal are not adequate. In order to expedite the work of the Bureau along this line, we should be provided with a well-equipped chemical laboratory.

There is also need for a well-equipped physical laboratory, where tests of stone, quicklime, cement, brick, terra cotta, sewer pipe, etc., may be made; and in which there are kilns suitable for testing materials which may be thought to be of value for the manufacture of pottery, terra cotta, brick, sewer pipe, cement, quicklime, etc. Such a laboratory should also contain machinery for testing materials to be used in the improvement of the public highways. Brick, stone, asphalt, cement and, in fact, all materials of this nature, have variable qualities, which can only be measured quantitatively by subjecting such materials to tests in the laboratory.

Requests for tests of this character now come to this Bureau, but until a laboratory with necessary equipment is provided, they cannot be made. This is the age of cement, brick, terra cotta and stone, and the testing of these products and the materials for their manufacture should be carried on systematically by some department of the state government.

There should be provided for the purpose of equipping chemical and physical laboratories, the sum of $6,000.

Topographic Maps. The geologic mapping in the state might be reduced one-half by first preparing topographic maps. Topographic maps are not only of assistance in geological work, but they are valuable in planning highway improvements, laying out drainage districts, conducting soil surveys, and in many other ways. These maps indicate, by contour lines, the hills and valleys; they locate accurately all streams and wagon roads; and, in fact, contain all the information desired for practical, educational, political, administrative, statistical and economic purposes.

The following summary shows the uses of topographic maps:

1. "*Educational.*—(a) By promoting an exact knowledge of the country; (b) by serving teachers and pupils in geographic studies.

2. *Practical.*—As preliminary maps for planning engineering projects. Highways, electric roads, railroads, aqueducts and sewerage plants may be laid out on them, and the cost of preliminary surveys may be saved. Areas of catchment for water supply, sites for reservoirs and routes of canals may be ascertained from these maps.

3. *Political.*—In all questions relating to political or legislative matters. For these purposes they afford accurate information as to the relations of boundaries and towns to natural features.

4. *Administrative and Military.*—In all questions relating to Federal or State administrations of public works, as canals, reservations, parks, highways and as military base maps on which to plan works of offense, defense, camps, marches, etc.

5. *Statistical.*—As base maps for the graphic representation of all facts relating to population, industries, products or other statistical information.

6. *Economic.*—As a means for showing the location, extent and accessibility of lands, waters, forests and valuable minerals. In this respect these maps are indispensable to State and Federal bureaus, and to owners, investors and corporations."

"In addition, as an incident in the making of a topographic map, monuments are established throughout the State, the positions of which are accurately determined by geodetic methods and which serve as datum points for all other Government, private and cadastral surveys. There are also established throughout the State bench marks or permanent monuments which furnish datum elevations for the future determinations of height in connection with all public or private engineering works. Meridian marks are established at each county seat, which aid local and county surveyors in determining the declination of their compasses and which thus greatly facilitate the search for old property lines."

"The maps that result from these co-operative surveys show, in different colors, both in the manuscript and in the published edition, the following principal facts:

1. Public culture, printed in black, which includes the exact plan of every road, lane, path, railroad, street, dam, public boundaries, names, etc.

2. The hydrography, or water, printed in blue, including all lakes, rivers, streams, swamps, marshes, reservoirs, springs, etc.

3. The relief, or surface forms, printed in brown, including the shapes of hills, valleys and ravines, their elevations and depressions, and the slopes of every rise or fall in its surface of the land."

"The topographic maps produced by co-operative surveys are engraved on copper and printed from stone. The co-operating States have the benefit of this publication without further expense, and the residents of the State, as well as its officials, may purchase the

maps at rates of 5 cents per sheet, or $2 per hundred." (Extract from a report of the Director of the U. S. Geological Survey.)

The United States Geological Survey has made topographic maps of several areas in Missouri during the last biennial period. One of these areas covers portions of Stone, Taney and Christian counties and the other portions of Macon, Shelby and Knox counties. These maps have been made to assist this Bureau in carrying on its geological investigations.

In a number of states the geological surveys have a co-operative arrangement with the United States Survey by which each bears one-half of the expense of making these maps. The United States Survey will make the same arrangement in Missouri, should a specific appropriation for co-operation be made. For example, if Missouri should appropriate $10,000 a year for co-operation with the U. S. Geological Survey, there would be spent in the making of topographic maps, in this state, the sum of $20,000 a year.

As an illustration of what is being done by other states in the way of co-operation, your attention is called to the following table, showing amounts appropriated biennially for co-operative topographic mapping:

Ohio	$50,000
New York	40,000
Oklahoma	20,000
Califorina	20,000
Connecticut	17,000
Kentucky	20,000
Maryland	10,000
Massachusetts	20,000
New Jersey	14,000
N. Carolina	8,000
Pennsylvania	30,000
West Virginia	30,000

There are now seventeen states co-operating with the United States Geological Survey in making topographic maps.

The United States Geological Survey have expert topographers in their employ, while were the state to undertake the preparation of these maps, without assistance from the Federal government, she would be obliged to develop a corps of topographers, requiring several years to reach the efficiency of those in the employ of the United States.

It is our earnest recommendation that there be appropriated for topographic maps in co-operation with the United States Geological Survey the sum of at least twenty thousand dollars ($20,000).

Publications. It is the intention to continue the preparation of county geological reports. In addition, we expect to publish re-

ports on special mineral resources covering the entire state. We may also take up the preparation of reports dealing with the physical geography of the state, to be used in the public schools.

In the way of economic reports, there should be prepared those covering "Petroleum and Gas," "Coal," "Barite," "Asphalt and Asphaltic Rocks" and "Lead and Zinc." We have issued a volume on "The Quarrying Industry" and have volumes on "The Lime and Cement Resources," and on "Materials for Highway Improvements" in preparation.

Recommendations. To carry on the work of this Bureau with the greatest possible efficiency the by-laws governing the Bureau should be amended in several particulars. These amendments should be such as to accomplish the following objects:

1st. The Board of Managers should be made non-partisan, by designating that not more than two of the Board should represent any one political party. Their terms of office should expire successively, one each year.

2nd. A new section should be added, making it lawful for the State Geologist, or any of his duly authorized assistants, to enter, examine or inspect any and all mines or lands in the state of Missouri at all reasonable times.

3rd. The Bureau of Geology and Mines should also be charged with the compilation of statistics showing the amount and value of the output of all mines, quarries, clay-working plants, lime kilns, cement factories and such other mineral stone or clay products as may be exploited in the state.

4th. A new section should be added authorizing the establishment of chemical and physical laboratories for examining ores, rocks, clays, minerals, water, brick, terra cotta, sewer pipe, cement, concrete, asphalt and any other materials that may be used in the construction of buildings or the improvement of the public highways.

5th. A new section should be added as follows:

"The Board of Managers may, during any biennial period, expend a sum, not to exceed one-half of the general appropriation for the maintenance of the Bureau, in the preparation of county reports, including geologic or topographic maps, or both. The Board is further authorized to enter into an agreement with the County Court of any county in Missouri to make such reports, provided one-half the cost of preparing and publishing said reports shall

be guaranteed to be paid by said county either from the treasury of said county or from private subscription."

Estimate of Appropriation. To carry out the provisions of the law creating the Bureau of Geology and Mines, as outlined in Chapter 110, of the Revised States of Missouri for 1899, and the amendments thereto, passed by the 41st General Assembly, the Board of Managers consider it necessary that the following appropriation be made:

For maintenance and support, including salaries and expenses of State Geologist, assistants and clerks	$31,500
For equipment for chemical and physical laboratories	6,000
For topographical mapping in connection with the U. S. Geological Survey	20,000
For printing, engraving, and preparing maps and other illustrations	7,000
Total	64,500

CHAPTER V.

OBSERVATIONS ON MINING DEVELOPMENTS IN MISSOURI DURING 1905-'06.

Missouri ranks eleventh in the value of her mineral resources, being surpassed by Pennsylvania, Ohio, Michigan, West Virginia, Colorado, Illinois, Montana, Indiana, California and Minnesota. The value of the mining products for 1905 was approximately thirty-seven and a half millions of dollars distributed as follows:

*Zinc	$9,091,943
*Lead	7,403,730
*Coal	7,147,665
Barite	111,811
Clay Products	5,639,318
Building Stone, Quicklime, etc.	3,756,722
Iron Ore	330,000
Petroleum and Natural Gas (estimated)	12,390
Cement (Portland) estimated	4,000,000
**Silver	12,900
Total	$37,506,479

From the above statement it appears that zinc still maintains the lead in the value of the mineral resources. Lead is second and coal third. There has been an increase in the value of all the products of the mines and quarries, the output as a whole surpassing that of any former year.

Asbestos. There are two fibrous minerals commonly known as asbestos. One is chrysotile and the other actinolite. The first named variety does not, to our knowledge, occur in Missouri, at least in deposits of commercial size. The second occurs in at least two localities, one in Iron county and the other in Crawford county.

The fibre of asbestos from these localities is long but brittle. The exposed portion of the veins are small and it is somewhat doubtful if they can ever be exploited economically.

Asphalt and Asphaltic Rock. The deposits of bituminous sandstone and limestone in the western part of the state remain undeveloped. The cheapness of the asphalt obtained from the distillation of petroleum in the western and southern oil fields

*From the report of the Bureau of Mines and Mine Inspection.
**From the report of the Director of the Mint.

has probably been a large factor in retarding the exploitation of the asphaltic rock of Missouri.

There are extensive deposits of asphaltic sandstone and limestone in the western part of the state, which might be used for paving. More detailed information regarding these deposits can be obtained by referring to the biennial report to the 43rd General Assembly.

Barite. This mineral, which is known variously as barytes, "ball tiff," "tiff," "heavy spar" and "spar" occurs associated with galena in many places over the Ozark region. It is one of the most stable compounds known and often occurs in a practically unaltered condition embedded in clay close to the surface. It also occurs in caves and fissures in the dolomite, sometimes in large, beautiful crystals.

The barite mined in Missouri occurs chiefly in the Potosi formation (dolomite), although there are deposits in younger formations of the Ozark region.

The chief producing areas are in Washington, Jefferson, St. Francois and Franklin counties. Barite has also been obtained from Miller, Morgan, Cole, Camden and Hickory counties. Texas, Crawford, Phelps and other counties also contain deposits of this mineral, most of which are undeveloped.

There are three factories in this state using barite, two in St. Louis and one in Mineral Point. Those in St. Louis are the "Nulsen, Klein and Krausse Mfg. Co." and "The J. C. Fink Mineral Milling Co." The one in Mineral Point is "The Point Mining and Milling Company."

The exploitation of this resource is being carried on in about the same manner that it has been for the past five years. The Southeast Missouri Barytes Company is the only company operating on a large scale. This company uses traction engines to haul the product from the mines to the station, and has otherwise sought to improve the methods of exploitation.

There are many deposits of barite in the Ozark region which have never been mined, on account of their distance from the railroad. These will sometime be valuable, and records should be kept of their location.

The total value of all barite mined in the United States in 1905 was $148,803. In contrast to this we note that the value of barite products imported into the United States during the same period was over $300,000. There should be some way by which

the barite producers of the United States might be enabled to supply this market now occupied by the European manufacturers.

Building Stone. The most important quarries in this state are located in the neighborhood of Carthage. The pure white limestone belonging to the Burlington formation is here known as the Carthage limestone. The quarries have been very active during the last two years and two new companies have come into the field, "The Carthage Superior Limestone Company," and The Missouri Stone and Construction Co. The uses for the stone are being multiplied, and everywhere there are evidences of increased activity.

The development of the granite quarries remains unchanged. The operators have not changed since the publication of the report on "The Quarrying Industry." The value of the output has changed very little.

One of the surprising things about the Granite quarrying industry is the slowness with which it develops. In several counties in southeastern Missouri there are extensive areas of granite, well adapted to all kinds of building constructions as well as monumental work. However, there is comparatively little interest in this resource and correspondingly slow development. For information on the granite quarrying industry, with map showing the distribution of the igneous rocks, reference should be made to Vol. II, 2nd Series of the reports of this Bureau.

At Hicks Station, "The Ste. Genevieve Stone and Construction Company" has opened a new quarry near the right-of-way of the St. Louis and San Francisco railroad. The quarry is in the Aux Vasse sandstone and is equipped with steam channeler, gang saws and other necessary machinery for operating on a large scale. This quarry is very favorably situated and the stone is of good quality for building purposes. It has a pleasing buff color. Mr. H. Ward Hicks of Ste. Genevieve is manager.

There have been some additional developments at the Regenhardt quarry at Cape Girardeau. The quarry has reached a depth of nearly one hundred feet. At a depth of ninety-five feet a ledge was encountered which takes a very excellent polish, having much the appearance of the Tennessee marble. The stone is solid and can be obtained in large dimensions.

The condition of the quarries at Hannibal, Warrensburg, Breckenridge and other places has changed very little since the publication of the report on "The Quarrying Industry."

The Hughes Stone Company has absorbed all the quarrying interests at Noel and Madge, and are now operating on a much larger scale.

Crushing plants have been installed at a number of places, notably at Princeton and Gilman.

Chat. The tailings from the concentrating plants of the lead and zinc districts are known as chat. In the Southwestern Missouri district they are chiefly flint, with some limestone. In the Southeastern Missouri district they are dolomite. The flint chat is sharper and much harder than the dolomite, and will therefore wear better in places where it is subject to abrasion. It is better when used in the construction of granolithic or granitoid pavements on account of its hardness, and it is preferable for street paving, because it will wear longer and proves to be less dusty and muddy. However, in concrete constructions, such as walls, basements, or foundations to pavements, the dolomite chat is equally as desirable as the flint. For railroad ballast there is practically no choice between the two. Neither is as well adapted to this use as rock crushed to a size of 1½ to 2 inches. It is much cheaper and has been used very extensively by all railroads entering the mining districts.

In the Flat River district chat can be purchased at the mines for about $2.00 a car, where it is to be used in the improvement of the public highways. In the Joplin district chat is sold at about 12½ cents per cubic yard or $3.75 to $4.50 per car to the railroads, and could probably be purchased at the same figure for paving. This provides a very inexpensive material, which is at all times accessible to the public for highway improvements.

It is thought that the chat of these districts constitutes a very important asset to the resources of the state. It should be used more extensively for the improvement of the public highways, and some arrangement should be made by which the railroads will haul it to distant points at a much less cost than at present. The rates which are now charged are almost prohibitive. Besides its use for highways, it might be used for the manufacture of artificial stone, electrical conduits, sewer pipes, etc.

VALUE OF PRODUCTION OF STONE QUARRIES BY COUNTIES IN 1905.

County.	Value of output.	County.	Value of output.
Adair	No returns.	Lawrence	27,200 00
Andrew	$21,120 74	Marion	110,070 00
Atchison	200 00	Mercer	64.644 55
Barry	208 50	Miller	10 00
Barton	880 00	Moniteau	500 00
Bates	5,842 50	Monroe	1,225 00
Benton	800 00	Montgomery	2,875 00
Bollinger	1,142 50	Lewis	2,225 50
Boone	1,865 00	Lincoln	86,878 77
Buchanan	7,786 80	Linn	1,185 00
Caldwell	42,970 80	Livingston	85 00
Callaway	650 00	McDonald	10,750 00
Cape Girardeau	117,840 50	Newton	700 00
Carroll	20,540 00	Nodaway	410 00
Cass	880 00	Osage	152 50
Cedar	800 00	Pettis	5,201 50
Chariton	416 00	Phelps	155 00
Christian	7,150 00	Pike	6,967 79
Clark	760 00	Platte	1,467 25
Clay	58,400 00	Polk	2,250 00
Clinton	2,185 00	Ralls	1,100 00
Cole	11,848 50	Ray	650 00
Cooper	2,000 00	St. Charles	14,848 60
Dade	75 00	St. Clair	12,775 00
Daviess	1,095 00	St. Francois	183,541 58
DeKalb	429 75	Ste. Genevieve	51,905 20
Franklin	57,024 90	St. Louis	1,282,855 27
Gentry	50 00	Saline	274 50
Greene	291,095 00	Shelby	122 50
Grundy	2,587 00	Sullivan	8,650 00
Harrison	100,100 00	Vernon	4,000 00
Henry	187,081 25	Warren	500 00
Holt	141 80	Webster	200 00
Howell	250 00	Worth	400 00
Iron	81,871 85	Wright	150 00
Jackson	841,885 00		
Jasper	295,905 46	Total	$3,355,909 92
Jefferson	51 00	Ballast used by railroads (incomplete)	400,818 00
Johnson	15,081 56		
Knox	850 00		
Lafayette	1,500 00	Total	$3,756,722 92

The above table is necessarily incomplete, and does not include the production of sand, for which our statistics are too incomplete for publication.

Clay Products. Clay has very little intrinsic value, and no market value unless it is very pure, as in the case of kaolin and flint fire clay, such as may be used in pottery and fire brick factories. Unless very near a large city, lands containing clay suitable for the manufacture of brick, are of very little greater value than similar agricultural lands. The value of the land may be influenced by the proximity of a supply of suitable, cheap fuel, either wood, coal or gas.

To be of value in the manufacture of clay wares a deposit of clay must, first, be near to transportation facilities,—competitive transportation facilities; 2nd, there must be an abundant market; 3rd, there must be a cheap, yet suitable, fuel supply. The success of the business then depends chiefly upon the ability to make a marketable product.

Missouri has an abundance of most excellent clay. Many of the deposits of clay are in close proximity to railroad or other

transportation facilities. There is an abundance of cheap fuel, both coal and wood. One of the most fortunate circumstances is the occurrence of an abundance of clay and shale in close proximity to the large cities,—St. Louis, Kansas City, St. Joseph, Mexico, Hannibal,— suitable for the manufacture of nearly every kind of constructional material manufactured out of clay.

In the swamp lands of southeastern Missouri there are abundant deposits of clay suitable for the manufacture of drain tile, which is needed for draining the lands. In the northern part of the state there are abundant shale deposits, from which brick and drain tile of superior quality can be made.

Missouri has within her confines sufficient clay to supply the entire Mississippi valley with all the brick, tile and terra cotta which will be required for centuries to come. Yet, there is not an over production today. We might say that there are not enough factories to supply the demands of our own people, if we take into consideration the uses to which brick and tile would be put, provided the factories were nearer the consumers. The distance which these must often be transported by the railroads, adds so greatly to the cost that other materials are often substituted. In the improvement of highways, for example, the consumption of drain tile should be increased a hundred fold, and it would be, were this product obtainable at a less cost.

There would probably be more brick and tile factories in the state did the people know the possibilities of the clay and shale occurring in the immediate neighborhood of their towns and cities. There would be more brick and tile used were the manufacturers conversant with methods by which these products could be produced more cheaply than at present.

To bring about a wider and more economical exploitation of this resource the state should provide laboratory facilities, where citizens might have clay or shale tested to determine its suitability for the manufacture of different kinds of clay wares. Experimental work of this character is in line with the other investigations carried on by this Bureau, and it is hoped that an appropriation may be made to equip and maintain a laboratory for this purpose. Other states not only maintain clay testing laboratories, but also schools wherein their youth are taught the art and science of clay-working.

The following table gives the value of the clay products manufactured in Missouri in 1905, by counties:

VALUE OF CLAY PRODUCTS BY COUNTIES FOR 1905.

County.	Value of product.	County.	Value of product.
Adair	$9,750 00	Linn	$18,625 00
Andrew	1,950 00	Livingston	18,150 00
Atchison	7,645 00	Macon	6,560 00
Audrain	58,576 40	Marion	900 00
Barton	850 00	Mercer	600 00
Boone	16,000 00	Moniteau	4,099 00
Buchanan	205,889 08	Monroe	7,000 00
Butler	8,000 00	Montgomery	380 00
Caldwell	2,620 00	Morgan	18,789 00
Callaway	72,820 00	Nodaway	15,585 00
Cape Girardeau	67,665 00	Perry	8,950 00
Carroll	20,667 41	Pettis	600 00
Cass	8,841 82	Pike	8,800 00
Cedar	2,400 00	Polk	2,000 00
Chariton	10,507 00	Putnam	1,650 00
Clark	2,600 00	Randolph	88,288 89
Cole	16,500 00	Ray	5,898 55
Cooper	12,968 88	Ripley	1,610 00
Daviess	1,700 00	St. Charles	16,000 00
Dunklin	8,250 00	St. Francois	1,200 00
Franklin	7,675 00	St. Louis	8,831,804 51
Gasconade	18,565 62	Saline	7,815 00
Gentry	4,950 00	Schuyler	750 00
Greene	2,567 50	Scotland	15,500 00
Grundy	2,770 00	Shelby	1,412 00
Harrison	8,450 00	Stoddard	2,000 00
Henry	70,586 98	Sullivan	9,150 00
Holt	10,200 00	Vernon	22,498 60
Howard	2,400 00	Warren	880 29
Howell	2,880 00	Webster	900 00
Jackson	278,230 67		
Jasper	7,000 00		$5,140,818 84
Jefferson	11,212 50	Not included in above are:	
Johnson	70,259 00	Terra cotta (estimated)	400,000 00
Knox	2,290 00	Burned clay ballast	99,000 00
Laclede	1,260 00		
Lafayette	16,499 74	Total	$5,639,818 84
Lincoln	4,100 00		

Coal. The output of coal in Missouri for 1905 was valued at over seven millions of dollars, according to the report of the state mine inspector. This is an increase over former years, and indicates that the industry is in a healthful condition. The most important coal producing counties in the order of their importance are: Lafayette, Macon, Adair, Randolph, Ray, Platte, Vernon, Barton, Bates, Henry, Linn and Putnam, all producing over $100,000 worth of bituminous coal. There were 488 companies operating in the state. There has been mined since 1840, approximately 88,059,950 put. There were over 10,000 men employed in and about the mines.

The coal occurs entirely within the Pennsylvanian series and chiefly within the lower portion, known as the Des Moines. The Upper, or Missourian, contains some coal, but as far as it has been explored, the seams are thin. The Des Moines consists chiefly of sandstone and shale, while the Missourian is chiefly limestone. The limestone gradually increases in abundance from the bottom to the top of the Pennsylvanian series.

The Pennsylvanian strata underlie about 33,000 square miles of

territory, or approximately 30 per cent of the entire area of the state. There has been mined since 1840, approximately 88,059,950 short tons of coal. Considering the coal to have a specific gravity of 1.30, this amount of coal would occupy in the ground about 2,167,629,526 cubic feet of space. A seam of coal 36 inches thick, covering one square mile of ground, would occupy 83,635,200 cubic feet of space. Computed on this basis, the area which has been actually mined in this state amounts to about 26 square miles. If one includes in the area mined such pillars as may be left standing in the mines, the area is about 35 square miles. This means that only one-tenth of one per cent of the area underlain with Pennsylvanian strata in this state has been mined.

Provided one-twentieth of the entire area underlain with Pennsylvanian strata contains an aggregate thickness of 3 feet of coal, it will require at the rate of 5,000,000 short tons a year, about 750 years to exhaust the supply. If the output increases steadily in the ratio that it has in the past ten years, a much shorter time will be required, probably from 300 to 400 years.

One-twentieth of the Pennsylvanian series may not contain an average of 3 feet of coal. It would probably be much nearer correct to say that one-fortieth of the area is underlain with seams of coal averaging 1 foot in thickness; one-sixtieth with coal averaging 2 feet in thickness; and one-one-hundred and twentieth with coal averaging 3 feet in thickness. If this latter estimate should be approximately correct, we would have the following conditions:

275 sq. miles coal—3 ft. seam	934,362,000 short tons
550 sq. miles coal—2 ft. seam	1,245,816,000 short tons
825 sq. miles coal—1 ft. seam	934,362,000 short tons
1,650 sq. miles coal	3,114,540,000 short tons
Amount mined to date	88,000,000 short tons
Remainder	3,026,540,000 short tons

Three billion short tons mined at the rate of 5,000,000 short tons a year would require—provided one-third is left in pillars or wasted—400 years. If the production should increase at the rate which it has during the last ten years, the coal deposits, —upon this estimate of the reserve,—would be exhausted in less than two hundred years; perhaps in 150 years.

We do not believe that this or the next generation will suffer for want of coal, but unless greater economy is exercised in exploiting the coal fields of this country, future generations will criti-

cise us for our wastefulness and extravagance. If individuals and corporations persist in plundering our resources, the government should step in and regulate their exploitation.

*Concrete Building Blocks.**—During the past two years there has been a rapid advance in the use of concrete building blocks in this state, and as this industry continually assumes greater importance increased attention is directed towards it.

A few years ago, there were no plants manufacturing concrete blocks in this state, but at present, small plants are operating in most of the large cities and in many of the smaller towns. The blocks are being used extensively for dwellings, factories and retaining walls, but more especially for foundations in the smaller cities.

The industry has been greatly injured in some localities by manufacturers who have paid very little attention either to the correct proportions of the ingredients to be used, or to the proper methods of manufacturing the blocks. In either case, the proportion of cement used often falls below that required for a first class product and the resultant blocks are neither impervious to water nor uniform in composition. This condition generally results either from ignorance or from an attempt to make the block at a cost at which it may be sold in competition with common brick.

Many patents relating to the method of manufacturing these blocks have been issued, and through them the quality of the block has been greatly improved. The patents have been directed chiefly towards the manufacture of a block out of which an impervious wall may be constructed.

The most important steps in the process of manufacture were the introduction of the staggered hole block and the two piece block construction. In the former, the block contains two series of openings, so placed that the web joining the front and rear faces is I-I shaped, making it more difficult for the moisture to penetrate the wall than in the case of a straight web. In the second method, separate blocks are made for the interior and exterior portions of the wall. These blocks are in contact only at the mortar joint. Where proper care is exercised, both methods of construction practically insure a dry wall.

The materials used in the construction of concrete blocks are Portland cement, sand, crushed stone or gravel and water. In order to insure the best results, these materials should be free

*By H. A. Buehler.

from organic matter or other impurities. The proportions of these materials used, varies with the kind of block manufactured. Where the block is homogeneous throughout, sand and cement are used in the proportions of four of sand to one of cement. This proportion is almost universally used in this state. Where a less amount of sand is used, the block is of inferior quality.

In blocks, known as faced blocks, which are not made homogeneous throughout, the exposed surface is generally made out of a mixture of two parts of sand to one part of cement, while the body of the block consists of a mixture of four parts of gravel (or crushed stone) and sand to one part of cement. A surface made with the above proportion of sand and cement is almost impervious, while the use of gravel or crushed stone in the body of the block, cheapens its construction without materially lessening its strength. Care must be taken to insure a perfect bond between the face and body of the block.

Chat or mine tailings, which are extensively used in granitoid work, and which occur in almost inexhaustible quantities in southeast and southwest Missouri, constitute a valuable material for use in the manufacture of these blocks. For this reason it is thought that this industry will become important in the mining areas.

The following estimated cost of manufacturing these blocks per square foot of surface is computed from returns received from forty manufacturers in this state, and are for (1) homogeneous, (2) faced blocks.

	I	II
Sand	3.6c.	2.1c.
Cement	7.3c.	3.1c.
Gravel		2.25c.
Labor	4.7c.	4.7c.
Total	15.6c.	14.15c.

The estimated cost of laying these blocks in the wall, averages five cents per square foot. The total cost per square foot, according to the above estimate, of the finished block in the wall is 20c.

A detailed discussion of this subject will be found in a report to be issued this winter on "The Lime and Cement Resources of Missouri."

Copper. The only development in the production of copper in this state is the erection of a smelter by the North American Lead Company. This company has opened up in its lead mines at Fredericktown what the company believes to be valuable deposits of sulphide copper ore.

The deposits in Shannon, Crawford and Ste. Genevieve counties are in essentially the same state of development as reported in my biennial report to the 43rd General Assembly.

Fullers Earth. It requires a somewhat peculiar combination of fine quartz sand and clay to make a first class fullers earth. Those qualities by which one can classify a quartzose clay as a fullers earth are best determined by making actual tests.

There are no deposits being exploited in Missouri at this time. Occasional samples are received from different parts of the state which appear to be fullers earth. A sample, from about ten miles south of Ava, has every appearance of being a first class fullers earth.

Fuller's earth is worth about $5.00 to $6.00 per short ton. The consumption in the United States, is about 40,000 short tons per year, used chiefly in the process of deodorizing, bleaching, and clarifying oils and fats.

Gravel. Under the head of gravel is included deposits from streams, lakes or other bodies of water, either present or ancient. The chief supply of this material is obtained by dredging from the Mississippi, Missouri, and Meramec rivers. The principal points at which dredging is done are Glasgow, Hannibal, Louisiana, Kansas City, Boonville, Bloomfield and near Fern Glenn. There are banks near Pacific, Webster Groves and other places from which gravel is also obtained.

The stream gravel is used chiefly for railroad ballast and concrete constructions, while the bank gravel is used chiefly for improving highways. The gravel at Pacific is especially well adapted for highway improvements. It consists of an intimate mixture of flint pebbles, clay and sand, which, when compacted, makes a hard, impervious surface.

The tailings, obtained from the concentrating mills, are frequently spoken of as gravel, but these are more appropriately considered under the head of "chat."

Iron Ore. All the iron ore produced in Missouri in 1905 was consumed by "The St. Louis Blast Furnace Company," of Carondelet, and "The Sligo Furnace Company," of Sligo. The total production of the state in 1905 amounted to 109,398 tons, valued at approximately $330,000.

The ore used by "The Sligo Furnace Company" was obtained from the Cherry Valley mine, at Cherry Valley, the Steelville Mine, at Steelville, and the Craig Mine at Goltra. These mines are all located near Sligo. The ore used by "The St. Louis Blast Furnace

Company" was chiefly purchased from mines located at Mudville, Leslie, DeCamp, Iron Mountain, Grandin, Salem, Kerrigan, Hendrickson, Jefferson City, Vulcan, Chaonia, Greenville, Salem, Poplar Bluff, Carson, Billings, Anderson, Republic, Palmetto, Bois D'Arc, Pomona, Birch Tree, Willard, Brookline and Emmet. The ore is both red and brown hematite.

The iron mining industry has received quite a stimulus during the last year, and many of the long neglected deposits have been opened up. Promising bodies of ore have been opened up in the vicinity of Billings and Republic; near Greenville and Williamsville; near Grandin; near Leslie; near Mudville, and near Steelville and Sligo.

It is interesting to note that some of these ore bodies are much larger than one would anticipate simply from an examination of the surface. For example, the red hematite ore at Mudville has been explored to a depth of about 100 feet. In the vicinity of Greenville, Wayne County, there are evidences at the surface of iron ore in a great many places. From a hasty examination one is led to believe that in the aggregate there may be several million tons of ore available in the area tributary to Greenville.

There is no evidence that the bodies of iron ore in this state are in any respect comparable in size with the deposits of the Lake Superior region. However, there are a great many relatively small bodies of iron ore, of excellent quality, and large enough to justify exploitation. The next few years will undoubtedly show an increased production.

Most of the ore bodies, which are now being exploited, are described in a report published by this Bureau in 1892, on "Iron Ores." The edition of this report is exhausted, but access to copies may be had in almost any of the public libraries in the state.

Lead and Zinc. The mining of lead and zinc in this state has been confined during the past two years to the already developed Districts in the Southeastern and Southwestern parts of the state. The producing areas in these districts have been extended and new ore bodies within the already developed areas have been opened up.

During the year 1905, there was produced 140,854 short tons of lead minerals, valued at $7,403,730; and 212,720 short tons of zinc minerals, valued at $9,091,943. The average price paid for galena in the Southwestern district was $61.61 per ton; for zinc blende concentrates, $44.55 per ton.* A very small proportion of

*From the report of the Mine Inspectors for 1905.

the galena produced by the mines of the Southeastern district is sold to smelters, it being mainly reduced to pig lead by the companies operating the mines. For this reason any valuation placed on the output must be an estimate based on current prices.

The following is a statement showing the amount and value of the output of lead and zinc minerals from each producing county in the state for 1905.*

VALUE OF ZINC AND LEAD PRODUCTION BY COUNTIES FOR 1905.*

County.	Value of Zinc Ore.	Value of Lead Ore.
Barry	$ 8,177	....
Benton	....	$ 2,666
Camden	....	9,689
Christian	7,254	8,248
Cole	....	10,420
Crawford	....	518
Dade	8,946	2,028
Franklin	1,887	65,846
Greene	44,408	88,980
Hickory	....	11,115
Jasper	8,020,855	1,528,427
Jefferson	14,247	15,408
Lawrence	512,412	19,881
Madison	....	686,569
Miller	....	6,264
Moniteau	5,192	8,448
Morgan	951	2,914
Newton	468,694	98,540
Oregon	8,000	....
Ozark	975	....
St. Francois	....	4,804,719
Washington	....	90,446
Wright	....	2,109
	$9,091,948	$7,408,780

During the last two years the Moniteau county mines at Fortuna have been abandoned, and for that reason this county is no longer an important producer. Jasper, Newton, Lawrence, St. Francois, Madison and Washington counties show a steady output. There has been an especially noticable increase in the output of the lead mines of St. Francois county where the companies have been operating up to their fullest capacity.

The chief developments in Jasper county have been in what is known as the sheet ground. With the development of these deposits there is a tendency to conduct operations on a larger scale than has been formerly customary in the District. Larger acreage and fewer but larger mills will be the result. There are very few reasons why operations should not be conducted on a much broader

*From report of Bureau of Mines and Mine Inspection, 1905.

scale than at present. The result of such a movement would be to preserve large bodies of low grade ore which under the present system are neglected and eventually forgotten.

In Lawrence county prospecting beyond the developed area east of Aurora, carried on in a somewhat desultory manner, has shown the occurrence of other ore bodies. This Bureau has sought to encourage prospecting in this area, believing that the tributary territory offers reasonable hope for the discovery of bodies of lead and zinc ore of commercial importance.

There are also extensive areas of unprospected land in the neighborhood of Stotts City, Wentworth, Neosho, Carthage, Granby and Sarcoxie, which should command the attention of those interested in developing lead and zinc mines.

Attention should also be directed to other counties in the central and southern Ozark region, throughout which more or less prospecting has been carried on. In Phelps county two companies have been organized to prospect and develop lands situated near Newburg. Other companies are drilling lands situated near Edgar Springs. On the lands near Newburg, galena, associated with barite, has been found in a well developed flint breccia. The locality was visited during the spring of 1906, and at that time there was a sufficient showing of galena to recommend additional development work. The formation is Ordovician dolomite. It is not the same as the formation in which the Joplin ore occurs. This fact, however, in no way argues against the possibility of ore occurring in commercial quantities.

In Ozark, Taney, Stone, Oregon, Howell, Texas and other counties some prospecting has been carried on, but everything has been on a small scale. It is impossible to state at this time what the future may develop for this region. We have not had an opportunity to investigate this section of the state, and our knowledge is altogether from reports sent to the office.

Near Greenville, in Wayne county, the Holliday-Klatz Land and Lumber Company has been prospecting an unusual deposit of zinc ore. The zinc at this place is sphalerite or blende disseminated through a dike of basic igneous rock, of a greenish-gray color. The size of the deposit has not been determined, but such development as had been carried on at the time of our inspection led to the belief that it was sufficiently important to warrant further exploration. Accompanying the dike is a twelve inch vein of quartz carrying values in gold, sufficient perhaps to be developed along with the zinc ore. The determinations of the zinc and gold

values in the dike and quartz vein were not made by this Bureau, but by an assayer, whom we believe to be reliable.

Some galena has been found in the vicinity of Doniphan in Ripley county, but so little exploration has been carried on in this area that we are unable to make any statement as to the possible outcome of these developments.

In the Madison county area of the disseminated lead district considerable development work has been carried on by the Mine LaMotte Lead and Smelting Company and lessees, by the Madison Lead and Land Company and by the North American Lead Company. All these companies are in good condition from reports received at this office. In addition to the work done by these companies several others have been prospecting land under option.

In the St. Francois county area of the Southeastern disseminated lead district prospecting with the diamond drill has been carried on uninterruptedly. Eight new shafts have been or are being sunk by the companies operating in this district, while the Federal Lead Company have unwatered the two shafts of the Central Lead Company, which were flooded as the result of a strike two years ago. To take care of the additional tonnage of ore from these mines there have been erected two new mills, while a third is to be constructed next year. These three new mills, combined, will handle a tonnage of 35 to 40 thousand tons of ore a day.

The investigations which this Bureau has been conducting to determine the origin and the manner of occurrence of these ores are about completed and it is expected to publish the results in a volume to be issued this spring.

In Washington, Franklin, Jefferson, Cole and other counties prospecting has been carried on in a small way and some ore is being marketed yearly. A short time ago our attention was called to some very good specimens of zinc ore (blende in limestone) obtained from a prospect in Boone county. Thus search for these important metals is going on over the Ozark region and spreading north across the Missouri river.

Manganese. Manganese occurs in various forms in different localities in the state. In the lead mines of Madison county it occurs in a soft earthy form commonly known as wad. In Wayne county it occurs with brown hematite, constituting a manganese iron ore. The extent of these deposits has not been determined. Samples of manganese from the S. E. ¼ Sec. 20, T. 33, R. 28W. and Sec. 5, T. 39, R. 3W., have also been examined.

Manganese occurs quite widely distributed over the southern

part of the state but nowhere is it known to occur in deposits of sufficient size to be considered workable. The value of manganese varies from $5.00 to $15.00 per short ton.

Mineral Paints. The principal paint pigments produced in this state are lead, zinc and barite. Some kaolin, pulverized limestone and soft red hematite, of an argillaceous nature, are exploited for this purpose. Very ferruginous clay has been mined and sold from this state, being classed as umber and sienna. The amount produced is not known.

The Picher Lead Company is now placing on the market in addition to their well known sublimed lead, a natural blue lead, having a steel blue color. The company claims that this pigment possesses durability, elasticity, toughness, smoothness, and color not possessed by other lead pigments. It is especially recommended for coating iron and steel.

Mineral Waters. In 1904 there were eighteen springs reporting sales of mineral water. The quantity sold was 333,204 gallons, valued at $53,741.* According to the above, Missouri ranks eighteenth among the states in the production of mineral water. The total number of mineral springs recorded by the U. S. Geological Survey as occurring in Missouri is twenty-six. This is of course only a fraction of the number actually existing in this state.

In 1892 this Bureau published a report on Mineral Waters, since which time no attempt has been made to further investigate this resource. The water supply of a state is one of its most important resources, and could be made, by judicious business management, a source of considerable revenue. In Illinois, for example, the sale of mineral waters amounts to over $3,000,000, annually. This Bureau is desirous of obtaining information as to the location and characters of mineral springs in this state, in order to assist in making these waters better known among our people.

Nickel and Cobalt. There has been a great deal of discussion relative to the occurrence of nickel and cobalt in the lead mines of Madison county. There is no question as to its occurrence in these mines, the only point being whether or not it can be recovered economically. The same class of nickel and cobalt sulphides occur in some of the mines near Flat River, especially in the abandoned mine on the land owned by the Union Lead Company. The reports from those who operated this mine and conducted the prospecting indicate that the property is underlain with irregular bodies

*From the reports of United States Geological Survey.

of nickel-cobalt sulphide ores, in the shape of lenses, usually disseminated through the limestone for a space of 20 to 30 feet.

The Mine La Motte company has for several years reported to the Mine Inspection department a large valuation in nickel and cobalt contained in old mattes from the lead furnaces. However, to our knowledge, nickel or cobalt have not thus far been refined at this place.

The Madison Lead and Land Company, owning the Catherine Mine, ship a small amount of nickel and cobalt sulphides. The North American Lead Company are erecting a refinery and expect to treat their own nickel and cobalt ores, of which they have a considerable quantity.

These sulphides occur everywhere associated with the galena, sometimes in sheets but often disseminated through the dolomite with the galena. In the latter case they can be discovered only by separation on the tables or from the matte after the lead has been smelted.

These ores all occur in Cambrian dolomite, known as the Bonne Terre formation.

Petroleum and Natural Gas. There have been very few developments in the oil and gas industry in this state. During the summer of 1906 a company has been drilling at various localities in St. Louis county, and have lately announced that gas was encountered, at a depth of 1,150 feet, near Rankin station. This bureau has not investigated the report and the quantity of gas is unknown. At least two holes over a thousand feet in depth have been sunk. In our biennial report to the 43rd General Assembly we said—"There is very little probability of encountering either gas or petroleum in large amounts in the small basin of Carboniferous rocks, upon which St. Louis is located. * * * * The structure of the region, combined with the restricted nature of the basin argues against finding either petroleum or gas in large quantities." We have no reason to change this opinion expressed two years ago.

The northwestern portion of the state, in which there has been very little prospecting, is the region most liable to produce commercial quantities of gas and petroleum. In that part of the state there exist most of the conditions known to be favorable to the production and storage of petroleum and gas. The structure of the region has never been carefully worked out, although the reconnoisance maps of the early geologists, published in 1872 and 1873, show the presence of flexures which may serve as caps to

reservoirs occurring within the Des Moines (lower coal measures) strata below.

A careful geological survey of this region, showing the folding or flexuring, would be an extremely valuable aid in prospecting for these fuels.

Onyx. Throughout the Ozark region there are caves in the dolomite and limestone formations. Some are large, extending underground for a half a mile or more, and others are small, merely caverns. Many of these caves were formed during an ancient erosion interval—not the present. These were later filled, in whole or in part with travertine, or cave onyx, as it is called. This onyx resembles the Mexican variety and often, when polished, exhibits beautiful surfaces, having a variegated coloring. It is seldom obtainable in large blocks free from flaws, for which reason attempts to exploit these deposits have been abandoned.

All the deposits of onyx have not been examined as to their quality but there is no apparent reason why some may not yet be profitably exploited.

Portland Cement* During the last biennial period, there has been an exceptionally active demand for Portland cement, and a corresponding activity in its manufacture. The plants at present in operation in this and adjoining states, have been unable to supply the demand and there has been considerable interest manifest in the erection of new plants, as well as increasing the capacity of those already in operation. .

The Atlas Portland Cement Company now operates at Hannibal, two distinct plants known as No. 5 and No. 6, each of which have a capacity of 5,000 barrels per day. The St. Louis Portland Cement Company, located at Prospect Hill, north of St. Louis, have recently increased their capacity to 5,000 barrels per day. The plant at Louisana, upon which preliminary work was started some three years ago, has not been completed, and no further work has been done, although the raw materials are present in inexhaustible quantity.

During the past year, the Kansas City Portland Cement Company, of Kansas City, Missouri, have started the erection of a plant, located on the Missouri river bluffs, directly north of Independence, Missouri. The plant will be completed in April, 1907, and will have a capacity of 2,500 barrels per day.

The Missouri Portland Cement Company, organized by parties

---

*By H. A. Buehler.

in St. Joseph, Missouri, contemplate the erection of a plant at Iatan, Missouri. The raw materials occurring in the vicinity of Princeton, are being investigated at the present time, to determine their suitability for Portland cement. Should the quantity prove sufficient, it is probable that an attempt will be made to erect a small plant at that place.

This State is well supplied with the raw materials necessary for the manufacture of Portland cement. Both the Hannibal and St. Louis plants are using limestones of Mississippian age. The shales belong to the Devonian and Lower Coal Measures strata, respectively. The eastern portion of the state is underlain with inexhaustible quantities of these materials, which, together with the Trenton limestone, occurring beneath the Devonian, make this an attractive field for Portland cement factories.

While the Lower Coal Measures do not contain limestones of sufficient thickness for Portland cement manufacture, the upper Coal Measures, occurring in the northwestern porton of the state, are well suppled with both materials. The basal portion of this formation consists of strata of limestone and shale, several of which are of sufficient thickness to be used. The limestone and shale to be used by the Kansas City plant occur in this formation and are the same strata used at Iola, Kansas. This formation is also exposed at Iatan and Princeton and should plants be erected at these points, the raw materials will be furnished by strata ocuring these points, the raw materials will be furnished by strata occurring in this formation.

The two plants at present in operation in this state have a capacity of approximately 5,500,000 barrels per year. The Kansas City plant will increase this capacity by 1,000,000 barrels per year, making a total capacity for this state of approximately 6,500,000 barrels.

A full discussion of the possibilities of the Portland Cement industry in this state, with numerous analyses of shale and limestone will be found in the report on "The Lime and Cement Resources of Missouri," to be issued this spring.

*Quicklime.** The activity in all lines of building construction during the last biennial period, has created an active demand for lime. In response to this demand, a number of plants have increased their capacity by the addition of one or more kilns. Three new plants were constructed in 1905. The first of these was erected by T. W. Ballew and located two miles south of Princeton,

*By H. A. Buehler.

Missouri. It consists of three kilns. The second plant, consisting of five kilns, was erected by "The New Union Sand Company," of St. Louis, and is located just north of West Kimmswick on the St. Louis and San Francisco Railroad. This plant is modern in every respect and is modeled after the eastern plants. One kiln has been erected by "The Cliffdale Lime Company" at Brickey station on the St. Louis and San Francisco railroad in Ste. Genevieve county.

"The Hunkins, Willis Lime and Cement Company" of St. Louis, have just installed a complete electrical equipment at their plant located at Mincke station on the St. Louis and San Francisco railroad in the western part of St. Louis county. This equipment includes a 125 H. P. Weber gas engine, 75 and 35 K. W. Westinghouse generators and motors to operate the coal conveyors, blowers, compressors, pumping plant and crushing plant. This plant has undoubtedly by far the best mechanical equipment of any west of the Mississippi river. The company is also erecting a kiln to be used exclusively for experimental purposes.

"The Ash Grove White Lime Association" has just installed a Clyde hydrating plant, at Ash Grove, and are now marketing hydrated lime. Two grades of hydrate are produced, the first is made from the best quality of Ash Grove White Lime and is known as Snowflake hydrate. The second grade is produced from a yellow dolomite which has a yellowish tint when burned and hydrated. It is known as Canary hydrate. This is the first attempt to produce dolomitic lime in this state in commercial quantity.

Throughout many of the plants there has been a general improvement in the mechanical handling of both the stone and lime. Several plants have built tramways in place of hauling the stone by wagon. Natural gas, piped from the Kansas field, has been introduced as fuel and is now being used by plants located at Joplin and Carthage. This fuel has been found to be very economical.

The general demand for lime in this state is still almost exclusively for building purposes. A small amount is sold for fertilizer and one plant has installed a small grinder to reduce the lump for this purpose. The high calcium hydrated lime produced by the Ash Grove company, should prove admirable material for fertilizing purposes. Several car loads of lime from this state are shipped weekly to the northern tanneries. During the past three years, a considerable quantity of the lime produced in the vicinity of St. Louis, has been used for purifying the city water supply.

The Trenton and Burlington formations still produce the great

majority of the output of lime from this state, although the plants located at Ste. Genevieve use the Spergen Hill formaion and plants located at Princeton and Amazonia use beds belonging to the Upper Coal Measures. These formations, however, produce less than one-tenth of the entire output.

The lime burned from the Trenton formation, is dark in color and is known as black lime, while that produced from the Burlington is white in color. The lime produced during 1905 was valued at $712,950.

This industry has been injured to a considerable extent by the shortage of cars. One of the plants visited recently had fifty car loads of lime upon the cooling floors with order of shipment for the same, but were unable to deliver same on acount of their inability to obtain cars from the railroad company.

Sand. One of the very important resources of this state is sand. The uses are many but the major consumption is for the manufacture of glass, for mortars used in building constructions, for foundry purposes, for locomotives and for filters.

This state is abundantly supplied with sand suitable for all these uses. The St. Peters sandstone at Pacific, Klondike and Crystal City is used for the manufacture of the highest grade of plate glass, and is suitable for the manufacture of other grades. It is also used for locomotive, foundry and other purposes.

Sand for mortar and locomotive uses is obtained from the Kaw river near Kansas City, the Piney river near Newburg, the Gasconade river at Gerome, the Missouri river near St. Joseph, Boonville and Glasgow and from the Mississippi river south of St. Louis, near Hannibal, near Louisiana and elsewhere.

Sand is also obtained for locomotive and foundry purposes at Klondike, Morley, Fruitland, Fayette, Joplin, Nevada and other places.

Sand used for the various purposes mentioned above should possess various qualities. For mortars it should be sharp and clean. For locomotive use it should be sharp and fine. For foundry use it should contain an admixture of clay but be free from alkaline earths and alkalies. For plate glass it should be nearly pure silica and free from iron oxide and all other ingredients that might cause discoloration. For the manufacture of ordinary bottle glass iron oxide and other impurities causing discoloration are not necessarily harmful. Any ordinary sharp sand, which is clean, may be used for filtering purposes.

The sand supply for the large cities is obtained chiefly from

the Mississippi, Missouri and Kaw rivers and is obtained by dredging. The St. Louis supply is now handled chiefly by two concerns but since the sand is obtained from the rivers by dredging there is no reason why these companies should control the market.

Silver. The report of the Director of the Mint for 1905 credits Missouri with the production of $12,900 worth of silver. By inquiry it is learned that this silver is obtained chiefly from the galena mined in St. Francois county. It is known that one of the companies recovers the very small percentage of silver in the galena.

Strontianite. There is only one deposit of strontium ore being exploited in the United States and this is located in Texas. The market for strontium is very limited and the small amount exploited in Texas has been shipped to Germany.

The only known deposit of strontium ore in this state occurs in Iron county, near Annapolis. No attempt has been made to develop it.

The sulphate of strontium (celestite) is valued at $20.00 to $50.00 per ton. The carbonate (strontianite) is valued at about $4.00 a ton.

The chief uses are in the manufacture of fireworks, in beet sugar manufacture and in medicine.

Trimbleite. A ferruginous, argillaceous, arenaceous dolomite, named Trimbleite, by J. H. Morland of Kansas City, occurs at Plattsburg. The deposit is one foot, six inches in thickness and at the surface has a buff to yellowish color as a result of weathering. The fresh stone has a bluish gray color and is hard when quarried. It occurs seven feet below the Plattsburg limestone of the Upper Coal Measures (Missourian).

The stone is being pulverized and used in the manufacture of tooth powder, polishing powder and toilet soap, by "The Trimbleite Company," with offices and factory at Plattsburg.

Tripoli. The chief output of tripoli in this state comes from Seneca, in the western part of Newton county. Small deposits occur in Miller, Morgan and other counties, being exploited under the name of "chalk" or "silicate."

The chief deposits in Newton county occur within a radius of ten miles of Seneca, extending westward into Indian Territory. The deposits occur in the Mississippian series and are the product of local decomposition of chert or flint, probably belonging to the upper portion of the Keokuk formation. The soft porous rock

constituting the tripoli is the result of decomposition of hard chert or flint through the action of meteoric water.

The beds of tripoli have a thickness of from 2 to 20 feet and are usually covered with 3 to 6 feet of sticky red clay. The color varies from pure white to a bright pink, depending on the content of iron oxide. In some portions of the deposits the tripoli is soft and friable; in other parts it is firm. In some places it contains nodules of flint and in other places it is mottled with iron oxide.

The tripoli deposits of this area are controlled by one company, which is engaged in the manufacture of flitters, blotters, abrasive powder, etc. The output is increasing each year and with the abundant supply of raw material at hand promises to continue for many years. The value of the output in 1905 was approximately $50,000.

Zinc. See Lead and Zinc.

MISSOURI BUREAU OF GEOLOGY AND MINES.

H. A. BUEHLER, Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BOARD OF GEOLOGY AND MINES

TO THE

Forty-Fifth General Assembly.

THE HUGH STEPHENS PRINTING COMPANY,
JEFFERSON CITY, MO.

MISSOURI BUREAU OF GEOLOGY AND MINES.

H. A. BUEHLER, Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BOARD OF GEOLOGY AND MINES

TO THE

Forty-Fifth General Assembly.

THE HUGH STEPHENS PRINTING COMPANY,
JEFFERSON CITY, MO.

TABLE OF CONTENTS.

BOARD OF MANAGERS.

His Excellency, Joseph W. Folk, Governor of Missouri, Ex-officio President of the Board.......................Jefferson City
Hon. Elias S. Gatch, Vice-President...................St. Louis
Prof. Edward M. Shepard, Sc. D., Secretary..........Springfield
Hon. L. F. Cottey.....................................Edina
Hon. C. L. Whitener..........................Fredericktown

LETTER OF TRANSMITTAL.

To the President, Governor Jos. W. Folk, and the Honorable Members of the Board of Managers of the Bureau 6f Geology and Mines:

Gentlemen—I have the honor to submit herewith a report on the work of the Bureau of Geology and Mines for the years 1907 and 1908.

Your obedient sir,

H. A. BUEHLER,

State Geologist.

CHAPTER I.

WORK OF THE BUREAU OF GEOLOGY AND MINES DURING 1907 AND 1908.

The work of the Bureau of Geology and Mines during the past biennial period has been devoted almost exclusively to problems pertaining to the development of the mineral resources of the State.

The prime objects in maintaining a Geological Survey or Bureau of Geology and Mines are purely economic, and while much of the work of the geologist appears to be purely theoretical and lacking in practical bearing to those unacquainted with the science, it is worthy of note that, in part at least, the development of our mining, quarrying, cement, lime, clay-working and similar industries is dependent upon the information obtained by the geologist and presented to the public through published reports.

It is the province of this Bureau to direct the conservation as well as the development of our mineral resources, and there is no other department of the public service to which the citizens of the State can turn for reliable information to bring about the elimination of waste so much desired. The usefulness of this Bureau may be judged to some extent by its extensive correspondence, embodying hundreds of requests, for the published reports as well as requests for the services of the staff. The services of the Bureau are sought because information is given without bias or prejudice by men trained in the profession.

The law under which the Missouri Bureau of Geology and Mines operates specifies, in general, the investigations which shall be conducted by this Bureau. The requirements of the statutes have been briefly summarized in the biennial report to the 44th General Assembly, as follows:

1st. To ascertain the relations existing between the different rock formations at or near the surface of the earth and prepare county reports containing maps, drawings and other illustrations setting forth these facts and giving the thickness, surface distribution, structure and characteristics of each formation.

2nd. To examine the metallic and non-metallic mineral resources, including stone, clay, cement, road materials, soils, water, lead, zinc, iron, coal, petroleum, asphalt, copper, baryta, sand, etc., publishing complete reports outlining their distribution and describing their manner of occurrence.

3rd. To collect, name and arrange a collection of specimens illustrating the geology and mineral resources of the State; also to assist the colleges and schools in the making of similar collections.

4th. To examine ores, rocks, soils, clays, and other mineral specimens for citizens of the State, reporting as to the kind and value of any specimen submitted for examination.

5th. To disseminate, everywhere, correct ideas as to the occurrence, origin, and relation of ores, minerals and rocks, for the purpose of increasing the general intelligence of the public on matters pertaining to geology and mining.

6th. To answer all inquiries relative to the mineral resources of the State.

7th. To examine, upon petition of fifty freeholders, lands upon which ores, clays, stone or other mineral resources of value may be thought to exist.

8th. To co-operate with the United States Geological Survey and other bureaus of the United States Government where benefit will accrue to the State.

During the past biennial period each of these divisions has received more or less attention.

The work for the period was planned by Dr. E. R. Buckley, former Director of the Bureau, who resigned April 30, 1908, to enter the professional field. The resignation of Dr. Buckley is a distinct loss to the State and a matter of keen regret to those associated with him in the work. During his administration the efficiency of the survey has been brought to a very high plane and this Bureau is now recognized as one of the best organized of the State Geological Surveys. Under his direction a systematic method of preserving records by the card catalog system was introduced. This system tabulates the accumulating geological data, which was formerly virtually lost in a mass of note books, in such a manner as to make it easily accessible to any member of the Survey. During his administration, nine reports were prepared and published. These deal with the natural resources of the State and are extremely valuable contributions to our knowledge of the mineral wealth of Missouri.

Personnel. The following persons have been employed permanently on the Survey during the past two years:

E. R. Buckley, State Geologist (Resigned April 30, 1908).

H. A. Buehler, (Ass't State Geologist to July 1907; State Geologist since May 1, 1908).

G. W. Crane, Geologist (Resigned August 1, 1907).

Frank Gahrtz, Draftsman.

During the field season of 1907, a number of temporary assistants were employed in field work, among whom were the following:

R. R. Rowley, Geologist.

C. F. Marbut, Geologist.

O. U. Stromme, Ass't Geologist.

O. W. Wheelwright, Ass't Geologist.

V. H. Hughes, Field Assistant.

C. R. Wood, Field Assistant.

V. H. Gottschalk, Chemist.

Mrs. W. J. McCaw was employed as clerk and Edward Morse as Janitor during the biennial period.

In addition to the above, the United States Geological Survey had a number of topographers in the field working in co-operation with the Bureau in the preparation of topographic maps. This is the first time that the State has assisted, in a financial way, in the preparation of these maps, and the result has been highly satisfactory.

Reports Published. The following five reports were published during the past biennial period. In part, they are the result of several years work and include all the investigations completed at the end of Dr. Buckley's administration.

(1) "Public Roads," Vol. V, 2nd series.

This report is devoted to a discussion of the materials necessary and methods employed in the construction of city pavements and country roads. The report should be in the hands of every County Court and road overseer in the State.

(2) "Lime and Cement Resources of Missouri," Vol. VI, 2nd series.

This volume includes chapters devoted to a description of the methods employed in manufacturing lime and cement; the nature of the raw materials from which they are made, and a general description of the suitable limestones and shales occurring in each county. It also includes a brief description

of each of the lime and cement plants operating in the State and outlines, in general, those areas favorable to a further development of these industries.

(3) "Geology of Morgan Co.," Vol. VII, 2nd series.
This is the third county report published since 1900. It describes in detail the various geological formations occurring in the county and dwells particularly upon the physiography and mineral resources of the area.

(4) "Geology of Pike Co.," Vol. VIII, 2nd series.
This volume covers a detailed survey of Pike county by Prof. R. R. Rowley of Louisiana, Mo. It is devoted largely to the paleontology of the area.

(5) "Geology of the Disseminated Lead District of St. Francois and Madison Counties." Vol. IX, 2nd series.
This report is the result of several years careful study by Dr. E. R. Buckley, former director of the Bureau. It includes a detailed study of the stratigraphy and structure of the region as well as a complete discussion of the genesis of the ore deposits. Four geological maps illustrate the relation of the ore to the geological formations and accurately outline the areas in which productive ore bodies have been found. The report is one of the most valuable yet published by the survey.

Geological Map. A new geological map of the State was published in 1907. It incorporates the results of all field work completed prior to the date of publication, and is of great value in outlining the area underlain by the Coal Measures, in showing the formations in which the lead and zinc ores are found, and in designating the occurrence and distribution of each of the geological formations in the State.

Report in Preparation.—At the time I became Director, there was in preparation a report on "The General Geology of Missouri." The manuscript is about two thirds completed and a number of the necessary illustrations have been collected.

The report is intended primarily as a guide to those interested in Missouri geology. Chapters are devoted to the methods of identification of the common minerals and rocks; to the classification and description of the different geological structures and to a discussion of the geological history of the State. Maps and illustrations will picture the more prominent and important geologic and topographic features. Chapters are also devoted to the economic resources of the state. This volume will be of great

educational value and should serve as a basis for school work in physical geography.

Unfinished Field Work.—Considerable field work, which is not embodied in reports already published, has been carried on in several sections of the State. The greater portion of this work was done during the summer of 1907. The areas under investigation will require additional mapping and study before the results will be available for publication.

This work has been mainly a study of the stratigraphy in those areas where the investigations will have a direct bearing upon the development of our mineral resources.

Geologic Mapping.—Mr. O. W. Wheelwright spent one field season in mapping the geology of Platte, Buchanan and Andrew Counties, the plan being to publish a report upon the Geology of Northwest Missouri. That portion of the State is underlain by the greatest thickness of the Coal Measures strata and therefore is considered the most favorable territory in which to prospect for oil and gas. A knowledge of the structure of this region is particularly important, in order to determine, if possible, the most favorable areas in which to drill for these fuels.

Messrs. O. U. Stromme and C. R. Wood spent one field season mapping the surface geology in the vicinity of the mining camps of Aurora, Wentworth, Stotts City and Sarcoxie. The results of this work are to be embodied in a report upon the Lead and Zinc District of Southwest Missouri.

The bodies of lead and zinc ore of Southwestern Missouri are closely related to the geological structures of the region. Maps showing these structures indicate the probable direction of the future extension of the mining districts and are therefore important in indicating the most favorable territory for prospecting.

The St. Peters sandstone, locally known as the "Pacific" or "Crystal City," was mapped over a considerable area in St. Louis, Franklin and Jefferson Counties by Mr. O. U. Stromme. This formation is the chief source of glass-sand in this State.

The mapping of this formation north of the Missouri river and south of Crystal City, along the Mississippi river, should be continued. The preparation of a map showing in detail the area covered by this formation, will be of value in indicating the region from which our future supply of sand will chiefly come.

Mr. V. H. Hughes spent one field season mapping the area underlain by the LaMotte sandstone, and locating the eastern

boundary of the Bonneterre dolomite on the Farmington quadrangle. The Disseminated lead deposits of Southeastern Missouri occur in the latter formation and this work is of importance in determining the possible limits of these deposits in both St. Francois and Ste. Genevieve Counties.

Drill Records.—During the past year a co-operative arrangement was made with the United States Geological Survey for collecting cuttings and records of well borings throughout the State. In accordance with this agreement the Federal Survey has forwarded to this Bureau all drill cuttings, and copies of all drill records which they have collected in this State. The information obtained by the Bureau from an examination of these records and cuttings is of value in showing the character of the rock formations passed through, and the depth at which water is encountered. At the present time the Bureau has not sufficient data at hand to indicate the depth and character of the water supply throughout a greater part of the State.

Topographic Mapping.—The last General Assembly made an appropriation for topographic mapping to be carried on in co-operation with the United States Geological Survey. While many of the states have, for a number of years, made appropriations to carry on this important branch of the work, this is the first expenditure of funds by Missouri for this purpose. The work completed prior to 1907 was entirely at the expense of the Federal Survey.

Under the terms of the agreement, one-half of the total expense is paid by the Government. The execution of the work is under the charge of the topographic branch of the Federal Survey.

The following sheets were completed under this co-operative agreement during the past biennial period.

Macon quadrangle	229 sq. miles.
Higdon "	236 " "
Weingarten "	236 " "

The Rolla quadrangle is also approximately two-thirds completed; 126 square miles having been mapped during 1908. This quadrangle will be finished during the spring of 1909. The work was temporarily suspended because of a shortage of funds. The early completion of this quadrangle is especially important because of the value of this map to the engineering and geological departments of the School of Mines.

In addition to the co-operative work the United States Geo-

logical Survey mapped 175 square miles in the western half of Platte County. This area was mapped with twenty foot contours on a scale of 2,000 feet to the inch. The work was carried out at the request of the Department of War for use of the garrison stationed at Ft. Leavenworth. The map will be useful to this Bureau as a base upon which to work out the geological structure of Platte County.

The total area mapped, topographically, during the years 1907 and 1908, was 1,002 square miles, including 287 miles of primary levels, 1,850 miles of secondary levels, 248 miles of primary traverse and 2,824 miles of secondary traverse. Sixty-four bench marks were established.

Laboratory Equipment.—During the past biennial period the Bureau has installed a well equipped chemical laboratory, which will greatly facilitate the work of the department.

The value of many of the undeveloped deposits of stone, clay, coal and metallic ores depends largely upon their composition, which can only be accurately determined by careful chemical analyses. While it is not the purpose of the department to undertake commercial work, many of the specimens collected by members of the staff require analyses to determine their value. Hundreds of specimens are also received from citizens who desire to know their probable value. In many cases careful tests are required to answer these inquiries. The equipment recently installed is adequate to serve the department in making both mineral and water analyses.

A Bausch and Lomb petrographic microscope with photographic attachment has been added to the laboratory equipment. This instrument is required for the study of thin sections of lead and zinc ores, and structural materials, including building-stone, cements and mortars. A number of drafting and field instruments were also purchased.

The above equipment places the Survey in a much better position to carry on its research work than it has been heretofore.

Library. During the past year the Survey library was moved to the room formerly occupied by the School of Mines library, on the second floor of the Survey building. Through the exchange of publications with other Geological Surveys and scientific institutions the usual additions have been made to the library during the biennial period. Approximately 350 volumes of geological reports and technical journals have been added in this manner.

Many of the reports of the scientific societies of America and Europe are received unbound, the complete volumes of which often consist of several parts. The technical journals received are also unbound. The Survey has never been provided with a fund to bind these volumes, and in an unbound condition they are almost valueless for reference. They contain much information of value to the department in conducting its researches, and since this is the geological library to which the members of the staff must refer, the volumes should be bound, thereby making the information which they contain easily accessible. It is estimated that the missing files can be completed and the more important of these volumes can be bound at an approximate cost of $800.

Museum.—The Geological Museum has been enlarged, so that it now occupies the entire eastern half of the first floor of the Survey building. New cases have been erected in that part of the room formerly occupied by the library. Many instructive specimens illustrating the economic geology of the State, which were formerly in the store room, have been unpacked and placed where they can be used for reference.

The Survey has a representative collection of fossils, building stone and lead and zinc minerals of the State. During the past biennial period, approximately 500 specimens have been added to this collection.

It is hoped in the near future to supplement this with a series of specimens showing the products of concentrating and smelting lead, zinc, iron, copper, nickel and cobalt ores. In addition to this there will be installed a collection showing the raw materials and manufactured products of clay, stone, baryta, sand, tripoli, etc.

Each series will illustrate, as far as possible, the method of treatment starting with the raw material and ending with the finished product.

Information Bureau.—One of the very important functions of the Geological Survey is in disseminating information regarding the mineral resources of the State. Thousands of letters are received each year requesting information concerning these resources. Many requests for information come from investors and capitalists who reside in distant portions of the United States. These inquiries cover practically every natural resource of the State, and the information given to such parties, through correspondence, must be of great benefit. Requests for information concerning the possibility of finding oil and gas and relative to

the iron ore deposits have been especially numerous during the past two years. All letters have been answered as promptly as possible and no matter how trival the request may have seemed, it has been given full consideration.

Demand for Reports.—The value of the investigations carried on by this Bureau is indicated, in a measure, by the demand for our published reports. Requests are received almost daily for copies of the reports published between 1890 and 1900. The editions of a majority of these reports are exhausted, but copies can be purchased at second-hand book stores in the larger cities. Probably there has never been a greater demand for the reports of the Bureau than during the past biennial period. As shown by the following list, a total of 5,165 volumes have been distributed during the past two years.

Vol. 12, Part 2	20
" 13,	25
" 1, 2nd series	103
" 2, " "	376
" 3, " "	301
" 4, " "	451
" 5, " "	510
" 6, " "	1011
" 7, " "	650
" 8, " "	538
44th Biennial	1180
Geological Map of Missouri	1500

At the present time the department has the following volumes for distribution. They will be forwarded to any citizen upon receipt of transportation charges.

	Postage.
Areal Geology, Vol. XII, Pt. 2, by C. F. Marbut and G. C. Broadhead	25c.
Preliminary report on Structural and Economic Geology, Vol. XIII, 1900, by Jno. A. Gallaher	25c.
New Year's Announcement, Jan. 1, 1901, by Jno. A. Gallaher	10c.
Biennial report of the State Geologist to the 41st General Assembly, by Leo Gallaher,	10c.
Biennial report of the State Geologist to the 39th General Assembly, by Charles R. Keyes,	10c.

Geology of Miller county, Vol. I, 2nd series, E. R. Buckley, A. F. Smith and S. H. Ball, 25c.

The Quarrying Industry of Missouri, Vol. II, 2nd series, 1904, by E. R. Buckley and H. A. Buehler, 40c.

Biennial report of the State Geologist to the 42nd General Assembly, by E. R. Buckley, 10c

The Geology of Moniteau Co., Vol. III, 2nd series, 1905, by F. B. VanHorn, 15c.

Biennial report of the State Geologist to the 43rd General Assembly, by E. R. Buckley, 10c.

Geology of the Granby Area, Vol. IV, 2nd series, 1906, by E. R. Buckley and H. A. Buehler, 20c.

Biennial report of the State Geologist to the 44th General Assembly, by E. R. Buckley, 10c.

Public Roads, Vol. V, 2nd series, by E. R. Buckley, 15c.

Lime and Cement Resources of Missouri, Vol. VI, 2nd series, 1907, by H. A. Buehler, 25c.

Geology of Morgan Co., Vol. VII, 2nd series, 1908, by C. F. Marbut, 15c.

Geology of Pike Co., Vol. VIII, 2nd series, 1908, by R. R. Rowley, 15c.

Geological Map of the State, 10c.

CHAPTER II.

FUTURE WORK OF THE BUREAU.

The interest which the general public is manifesting in the State's resources in coal, lead, zinc, clay, baryta, oil and gas demands that a greater portion of the time of this Bureau be devoted to a study of these deposits.

Economic reports upon these subjects should include not only a discussion of the occurrence and value of our mineral deposits, but should also, where possible, point out the dangers of early exhaustion through wasteful methods of mining and milling. An important factor in the future industrial supremacy of this country involves the present conservation of our mineral resources through better methods of exploitation. This is equally true of the several states of the Union.

It is doubtful if more than sixty per cent of the coal in the ground is recovered in many of the coal mining districts of this State. In the lead and zinc district of Southwest Missouri, the methods of mining and milling in conjunction with the present methods of leasing, make the average recovery for the district less than fifty per cent of the mineral in the ground.

It is the province of this Bureau to direct attention to this waste and to make such suggestions as may materially increase the recovery.

Geologic reports covering the following subjects should be prepared as early as possible.

Coal.—Coal is one of the most important mineral resources of the State. In 1907, Missouri produced coal which was valued at $7,306,125. The Coal Measures underlie approximately 25,000 square miles in the western and northwestern parts of the State. With the exception of a few isolated areas, but little detailed study has been made of the Coal Measures and no accurate knowledge is to be had concerning the probable extent of the workable coal seams.

In 1897, this department published a brief preliminary report on the coal deposits being worked at that time. This report is

mainly descriptive, outlining in general the thickness and gen nature of the beds occurring in the several areas which were b worked at that time. The information contained in this re was in such great demand that the entire edition was soo hausted. This volume can now be obtained only by purchase second-hand book stores.

Many requests are received annually for a comprehe port dealing with this industry. Such a report shoul complete study of the geologic occurrence of the c results of such laboratory and boiler tests as will d relative fuel values of each bed. These tests should those carried on at the fuel testing plant of the United States Geological Survey at Pittsburg, Pennsylvania.

The importance of such a report is emphasized by the recent discovery in the northern part of the State of valuable coal seams at depths of from 450 to 500 feet. These beds are reported to be from 3 to 5 feet thick and may be a part of one of the important undeveloped areas. The Survey should give special attention to this field at an early date.

Oil and Gas.—Altho Missouri produces practically no oil or gas, there are no other possible natural resources in which the public is taking a greater interest at this time. Citizens in every section of the State and many large producers of oil and gas operating in the productive fields of the eastern and central portions of the United States, are actively interested in this subject. The extensive development of the Kansas-Oklahoma field and the phenomenal growth of the Illinois field, which has been developed during the past three years, has centered the attention of oil and gas men upon Missouri, which lies between these productive areas.

Thousands of acres of land have been leased in different portions of the State. Large tracts, aggregating from 30,000 to 50,000 acres, are being leased by individual companies, the majority of which are substantial producers in other fields and are not promoting stock selling schemes.

During the past year wells have been drilled or started in Phelps, Dent, St. Charles, Harrison, Knox and Johnson Counties. Some of these counties do not give any geological evidence that oil or gas will ever be discovered within their boundaries.

Most of the oil and gas obtained from the Kansas-Oklahoma and the Illinois fields occurs in the sandstones of the Coal Measures, and it is believed that the same series in Missouri is the most favorable to the discovery of these mineral fuels.

The Coal Measures occur mainly in the northwestern portion of this State, being the northern extension of the same series occurring in Kansas and Oklahoma. These series have a maximum thickness in Missouri of approximately 2,000 feet, the lower portion of which consists mainly of sandstone and shale, which are thought to be so related as to afford the proper geologic conditions for the retention of oil and gas.

It is well known that the accumulation and retention of oil and gas in any area are dependent upon certain structural features that have never been worked out in detail for the northern portion of the State. In order to determine the most favorable territory for prospecting, a study of the structure of the region should be made at once. Such an investigation should include the gathering of all data on well drilling throughout the State and should summarize our present information concerning the thickness and structure of the various geological formations underlying the different sections of the State.

Such a report will not only serve to direct prospecting into those portions of the State where oil and gas may be discovered in commercial quantities, but will also serve to discourage drilling in those sections in which there is no possibility of finding these fuels. At the present time thousands of dollars are being wasted drilling in certain areas in Missouri where there is not the remotest possibility of finding either oil or gas.

Lead and Zinc.—Probably no investigations carried on by this Bureau are of greater value than those in the lead and zinc districts of the State. In 1907, Missouri stood first among the States in the production of both metals, the combined value of the lead and zinc ore productions being approximately $19,000,000.

At the present time mines are being operated in twenty-three counties in the State. The workable deposits are largely segregated into mining districts, each of which has distinctive geologic characteristics, a knowledge of which is important in the discovery and development of new ore bodies. There are a number of important areas for which detailed reports have not yet been prepared, and the investigation of these should be taken up at an early date.

At the present time the Bureau has for distribution only two volumes pertaining to lead and zinc: Vol. IV, devoted to the Geology of the Granby Area of Southwest Missouri, and Vol. IX, devoted to the Geology of the Flat River-Bonne Terre area of

Southeast Missouri. Each volume is an important contribution to our knowledge of the occurrence of lead and zinc in this State. However, they include only a very small part of the region requiring investigation. More or less attention should be given to the entire southern half of the State, and at least one geological party should be engaged continually in investigating the areas tributary to the productive fields.

During 1906, small areas tributary to Stotts City, Sarcoxie and Aurora were mapped. During the past season, however, this work was discontinued, due to a shortage of funds. These investigations should be resumed as soon as possible. Other important areas that should be surveyed occur in Franklin, Washington, Iron, Madison, Howell, Lawrence, Newton, Dade and Jasper Counties in the southern portion of the State.

Iron Ore.—Workable deposits of iron ore occur in forty-eight counties in the State. The most valuable of these are located in the Ozark region. While Missouri is not now an important producer of iron, the possibility of a much greater development is apparent when one reflects that a conservative estimate of the iron ore available is approximately 100,000,000 tons.

In 1892, this department published a report upon the iron ores of the State, but the edition has long since been exhausted. The increased interest manifest at present in these deposits makes their investigation an important subject for consideration.

Other Economic Reports.—While the deposits enumerated above should receive early attention, reports should also be published covering the baryta, copper, tripoli and glass sand deposits. Missouri produces more baryta and tripoli than any other state in the Union and has inexhaustible deposits of excellent glass sand. These deposits have never been studied systematically by this Bureau.

County Reports.—During recent years the Survey has published detailed reports on Miller, Moniteau, Morgan and Pike Counties. These reports are important contributions to the geology of the State and should assist materially in giving direction to any effort that may be made to develop the mineral resources.

The economic importance of the brick, stone, tile, cement and sand industries in the vicinity of our larger cities, demands the preparation of reports covering Buchanan, Jackson and St. Louis Counties. Field work should be carried on in at least one of these areas during the coming season.

Water Powers.—The Survey is continually receiving requests for information concerning the water powers of the State. Up to the present time, practically no attention has been given to this branch of our natural resources. The important streams of the Ozark region apparently offer opportunity for the development of sufficient power for heating, lighting and transportation throughout the southern half of the State.

A thorough study of this problem will require gaging stations along all the important rivers in order to determine the volume and variations of flow. As several years are often required to obtain sufficient data upon which to base accurate calculations, this work should be started at once.

Suitable arrangements can no doubt be made with the United States Geological Survey to carry on this work under a co-operative agreement. Such an agreement will greatly lessen the cost to the State and has the additional advantage of commanding the services of a trained corps of engineers now in the employ of the Federal government.

Topographic Maps.—The general importance of accurate topographic maps can hardly be over estimated. These maps show the surface features of the land, locating accurately all hills, valleys, rivers, lakes, springs, etc., as well as all roads, railroads, buildings, bridges and electric lines. Permanent bench marks are also established from which local surveys can be started. The value of these maps to the State and Federal governments may be judged from the following uses quoted from a recent circular published by the United States Geological Survey.

"(1) By the Federal Government.

The State Department—

In connection with questions relating to international boundaries.

The Treasury Department—

The Life Saving Service—

In connection with the location of life-saving stations and boathouses.

The War Department—

The General staff, the War College and the Service Schools—As a basis for military maps, in studies of military operations and problems, in historical studies of military campaigns and in map maneuvers ("war game").

The troops—

In maneuvers of the Army and the National Guard.

The Corps of Engineers—

In connection with work on the improvement of rivers and harbors, as base maps for the representation of information needed for office reference, and as a basis of plans for land defense of seacoast forts.

The Office of the Chief of Artillery—

In the Field Artillery: In the preparation and solution of problems in miner tactics and strategy.

In the Coast Artillery: In the preparation of plans for land defense and seacoast fortifications.

The Signal Corps—

In the establishment of wireless-telegraph systems, in the construction of telegraph land lines, and in ballooning.

The Quartermaster-General's Office—
In connection with the development of water supplies for military posts.
The Post Office Department—
In the preparation of post-route maps, and in the administration of the rural delivery service.
The Navy Department—
The United States Marine Corps—
In solving military problems and for use by troops in road marches.
The Department of the Interior—
The Geological Survey—
As base maps for the sheets of the geologic Atlas of the United States in surveys, made to determine the mineral resources of the country, in the classification of the public lands, and in the study of various geologic problems, many of which have an economic bearing. In hydrographic surveys, made for the purpose of determining and classifying the country's water resources, both surface and underground.
The General Land Office—
In the compilation of maps and in connection with the survey and sale of public lands.
The Reclamation Service.
In irrigation projects in the arid regions.
The Office of Indian Affairs.
In connection with allotments to Indians on Indian reservations.
The Department of Agriculture.
The Forest Service.
In the compilation of Forest Atlas folios for use in determining questions of sale, free use of timber, and grazing; in trail construction and other improvements in forest lands and as a base for field investigations.
The Bureau of Soils.
In plotting the character and extent of the various soils of the country.
The Bureaus of Animal and Plant Industry.
In investigations for the improvement of the plant and animal industries of the country.
The Weather Bureau
In connection with the establishment of river gaging station to determine suitable locations and exact elevations.
The office of Public Roads.
In determining routes, mileage, location of road-building materials and topography in country traversed by public highways.
The Office of Experiment Stations.
In drainage and other investigations.
The Biological Survey.
In traveling through little known regions, in laying out field work, in locating and mapping the boundaries of the life and crop zones, and in mapping the geographical distribution of plants and animals.
The Bureau of Entomology.
In plotting the distribution and spread of injurious insects.
The Department of Commerce and Labor.
The Coast and Geodetic Survey.
For obtaining geographical and topographical data outside of the limits of Coast Survey work.
The Light House Board.
In compiling charts for annual reports and for general office reference.
The Bureau of the Census.
In defining the enumeration and supervision districts, in assisting special agents in planning routes of travel, and in preparing maps to illustrate Census reports.
The Bureau of Fisheries.
In physical and biological surveys of lakes and streams in connection with the stocking of interior waters with food fishes and in locating fish-cultural stations.
The Smithsonian Institution.
In planning field trips, including determination of routes of travel and the establishment of camps or bases of supplies.
The Bureau of American Ethnology.
In field work for locating tribes and archeological sites, and in plotting data for file and publication.
The United States Geographic Board.
In the study of questions presented for the Board's decision.

The International Waterways Commission.
In the study of locations and routes of waterways.
(2) By States.
(a) In connection with co-operative agreements with the United States Geological Survey, or with other Government Bureaus.
(b) By State Geological or other surveys.
(c) By State Agricultural colleges.
(d) In good roads investigations.
(e) In connection with legislation involving county or town boundary lines.
(f) In connection with legislation involving the granting of charters, rights, etc., where a physical knowledge of the country is desirable or necessary.
(3) By engineers, for whom the maps serve the general purposes of preliminary surveys.
(a) For location of railroads, canals, highways, trolley lines, etc.
(b) For providing a water supply for municipal use or for power.
(c) In connection with problems involving land drainage or irrigation.
(d) In connection with sewerage systems.
(4) By miners, in prospecting for and locating mineral deposits.
(5) By educational and scientific institutions, in many ways.
(6) As a means of information.
(a) By land investors, through map representation of local conditions.
(b) By travelers or tourists, as guide maps."

Co-operative topographic mapping should be continued during the next biennial period. In order to work out the detailed stratigraphy and structure of northwest Missouri, a number of these quadrangles should be completed as soon as possible. As explained in former biennial reports, where co-operation with the Federal Survey is secured the Government pays one-half of the total cost of making these maps.

Educational.—That the people of the State may be better informed regarding our natural resources and be better able to recognize minerals of economic value the geological survey should devote considerable attention to educational work.

Such work can be done in three ways: 1st, by publishing a series of educational bulletins, describing the general geologic and topographic features of the State; 2nd, by making up a series of mineral specimens for use in the high schools; 3rd, by maintaining a permanent exhibit of minerals and structural materials at the State Fair.

At the present time the Survey has in preparation a volume on the General Geology of Missouri. It is hoped to complete this report during the coming year.

Appropriation Required.—In order to carry on the work as outlined in the preceding pages, it is earnestly recommended that the following appropriation be made:

For maintenance and support	$35,000
For printing and illustrating reports	5,000
For Topographic Mapping in Co-operation with the United States Geological Survey	20,000
Total	$60,000

CHAPTER III.

FINAL REPORT OF DR. E. R. BUCKLEY.

The following is the final report made by former Director Dr. E. R. Buckley to the Board of Managers. It is included in the present biennial report mainly for the purpose of showing changes in the existing laws proposed by one who has done much to bring the Bureau to its present plane of usefulness.

To the President, Gov. Joseph W. Folk, and the other Members of the Board of Managers of the Bureau of Geology and Mines, Jefferson City, Mo.:

Gentlemen—I was elected Director of this Bureau at a meeting held in St. Louis, August the 12th, 1901, and took active charge of the administration of the affairs of the Bureau September the 12th, 1901. My resignation was tendered to the Board at the October meeting, 1907, and took effect April the 30th, 1908. I have served as State Geologist and Director of the Bureau of Geology and Mines for a period of six years, seven months and eighteen days. During this period there has been spent in the neighborhood of $10,000.00 a year, with the exception of the year just past, when the appropriation amounted to $15,000.00.

Upon taking charge of the Bureau I found it not only deficient in equipment, but altogether disorganized and with practically no work in shape for the publication of reports. All of the reports which have been published during the period of my administration, with one exception, are entirely the result of investigations carried on during this period. The report on Pike county, which is Volume VIII., 2nd Series, was in part prepared during a former administration. Including this volume, there have been prepared and made ready for publication during my administration nine volumes of reports, while the manuscript for a tenth volume is practically complete. In addition to these reports, there have been published by the United States Geological Survey, at the request of this Bureau and through co-operation, ten fifteen min-

ute topographic sheets covering an area of, approximately, 1,350 square miles. In addition to this, the United States Geological Survey has mapped one thirty minute sheet which covers an area of over 500 square miles. These maps and reports are in addition to the regular biennial reports submitted to each session of the General Assembly, of which three have been published.

The following is a list of the reports made ready for publication during my administration:

Vol, I, 2nd series, Geology of Miller County, 1903, E. R. Buckley, A. F. Smith and S. H. Ball, Pages 197, Plates 18, Figures 56.

Vol. II, 2nd series, The Quarrying Industry of Missouri, 1904, E. R. Buckley and H. A. Buehler, Pages 347, Plates 59.

Vol. III, 2nd series, The Geology of Moniteau County, 1905, F. B. VanHorn, Pages 100, Figures 25.

Vol. IV, 2nd series, Geology of the Granby Area, 1906, E. R. Buckley and H. A. Buehler, Pages 114, Plates 42, Figures 3.

Vol. V, 2nd series, Public Roads, Their Improvement and Maintenance, E. R. Buckley, Pages 115, Plates 30.

Vol. VI, 2nd series, The Lime and Cement Resources of Missouri, H. A. Buehler, Pages 241, Plates 36.

Vol. VII, 2nd series, The Geology of Morgan County, C. F. Marbut, Pages 94, Plates 19, Figures 19.

Vol. VIII, 2nd series, The Geology of Pike County, R. R. Rowley, Pages 116, Plates 20, Figures 13.

During the last field season, we had parties in the field doing work preliminary to the publication of reports on the fuel resources of Andrew, Buchanan and Platte counties; and on the lead and zinc resources of the areas tributary to Sarcoxie, Wentworth, Stotts City and Aurora. Geological maps were completed covering the areas in the immediate vicinity of these places, and with a little additional work covering an examination of the mines a report could be made ready for publication.

The geology of the Farmington quadrangle has been about two thirds mapped and could be completed with part of a season's field work by one man. The St. Peters sandstone has also been mapped between the Missouri river at Labadie and the Mississippi river at Crystal City.

In addition to the above reports published by the Bureau during this period, we have answered thousands of letters of inquiry relative to the mining resources of Missouri, and have examined hundreds of specimens which have been sent to us yearly

for inspection. There has been no inquiry made by citizens of this State which has not received our careful and conscientious considerations, no matter how trivial that inquiry may have seemed.

We have also visited many parts of the State in answer to requests from Commercial Clubs and citizens who have petitioned us to assist them to determine where to prospect for minerals, fuels, etc.

As a result of our investigations we have been able to establish certain theories to account for the origin of the lead and zinc ores in the southern part of the State. These we believe to be of very great service to those who are engaged in mining these metals. The data upon which our theories are based have not all been published, but it is the hope that they will be printed and ready for distribution before many months.

Since taking charge of the Bureau, some important additions have been made to the equipment, both physical and chemical, and it was expected that during the present year more apparatus would be purchased out of the appropriation made for that purpose by the last Legislature.

The Museum and Library have both been completely overhauled, the specimens and books being systematically catalogued and arranged in the cases and on the shelves in the Library and in the Museum. Several thousand volumes of reports and pamphlets have been added to the Library and several thousand specimens have been added to the Museum collections.

Upon taking charge of the Bureau, I inaugurated a card system of cataloging the information obtained by the Bureau relative to the mineral resources of the State. For the last five years we have been constantly adding to the information contained in this catalog, until at the present time it is very useful in answering inquiries relative to the natural resources of the State. The system of cataloging this information is fully described in the biennial report to the 42nd General Assembly.

As a result of observations made during my administration, I feel that this Bureau is one of the important departments of the State government. I believe, however, that legislation should be enacted whereby its efficiency will be very greatly increased. I believe that the Bureau of Mines and Mine Inspection should be consolidated with this Bureau, and that the Mine Inspectors should be required to report to the Director of this Bureau and that they

should be directly under his supervision, as contemplated by the following bill which was passed by the Senate in the last legislature, but which was not brought to a vote in the House.

"BE IT ENACTED BY THE GENERAL ASSEMBLY OF THE STATE OF MISSOURI AS FOLLOWS:

That section 8817 of the Revised Statutes of the State of Missouri, 1899, and an act entitled "An act to amend section 8817, Article 2, Chapter 133, of the Revised Statutes of the State of Missouri, 1899, relating to the establishment of the bureau of mines, mining and mine inspection and the appointment of mine inspectors with emergency clause," approved April 13, 1903, and an act entitled "an act to repeal section 8818 of Article 2, Chapter 133 of the Revised Statutes of Missouri of 1899, and to enact a new section in lieu thereof," approved March 27, 1901, and an act entitled "an act providing for the practical and technical qualifications of mine inspectors, mine managers, mine foremen, assistant foremen, mine examiners and hoisting engineers and for the creation of a State mining board, its qualifications, duties and compensation," approved April 4, 1903, be and the same are hereby repealed and the following sections to be known as sections 5817-8818a and 8810a enacted in lieu thereof.

Section 8817—The president of the board of managers of the Bureau of Geology and Mines, shall, by and with the approval of the board, appoint four inspectors of mines who shall, be men of practical mining experience, upon the recommendation of the director of the Bureau, who shall accompany such recommendations with a statement setting forth the fitness and eligibility of all candidates. Each of said inspectors shall hold office until his successor is appointed. The inspectors, in the performance of the duties and exercises of the powers conferred upon them shall be under the control and supervision of the said board of managers, who shall have the power to fix the salaries of said inspectors and to remove them for incompetency, insubordination or other good and sufficient reason. It shall be the duty of the said board of managers to submit to each general assembly a report which shall cover in full the work of mine inspectors for each biennial period, explaining in full the condition of the mines, as regards sanitation, safety, the uses of oil, explosives, fencing of mines, signaling, blasting, ventilation of shafts, traveling ways, boilers, scales, timbering, qualifications of miners, etc., as regulated by law.

Section 8818—The inspectors provided for in this article shall

see that every necessary precaution is taken to secure the health and safety of the workmen employed in any of the mines in the State, and that the provisions and requirements provided for in this article be faithfully observed and obeyed, and the penalties of the law enforced.

Section 8818a—There is hereby transferred to the Bureau of Geology and Mines, all instruments, books, charts, cabinets, records, collections and other property of the State of Missouri heretofore under control of the Bureau of Mines, Mining and Mine Inspection.

Section 8819a—A fee for the inspection of each mine to be made twice each year shall be paid by the person or corporation owning or operating said mine as follows: The fee for the inspection of a mine employing ten men or less, shall be 50c. The fee for the inspection of a mine employing more than ten men, but not more than twenty men shall be $5.00. The fee for the inspection of a mine employing more than twenty men, but not more than fifty men shall be $10.00. The fee for the inspection of a mine employing more than fifty men shall be $10.00 for the first fifty men and $2.00 for each additional fifty men or fraction thereof employed. Such fees shall be paid to and received by the inspector making such inspection at the time such inspection is made and shall be paid into the general revenue fund of the State.

The fact that there is at present no official head to the Bureau of Mines and Mine Inspection, creates an emergency in the meaning of the constitution, therefore this act shall be in force on and after its passage and approval."

The enactment of such a law as that outlined above will increase not only the efficiency of the mine inspection, but will materially lessen its cost. The mine inspector under this Bureau would be able to collect a great deal of information which it is now necessary for each Bureau to obtain independently.

This Bureau should be charged with the investigation of paints and paint pigments, as outlined in the following bill, which might be combined with the bill intended to perfect the organization of the department, which is given on pp.

Be it enacted by the General Assembly of the State of Missouri as follows:

Whereas, the people of the State of Missouri are unacquainted with the suitability of the various ingredients used in the manufacture of mixed and prepared paints, white lead and oils;

Therefore, be it enacted, that the Bureau of Geology and Mines be, and hereby is directed to make tests, as hereinafter provided, of paint pigments, including the sulphate of lead, carbonate of lead, oxide of zinc, lead, lithaphone, barium sulphate, silica, kaolin, magnesium compounds, calcium compounds, and any or all other paint pigments with linseed oil, turpentine, Japan drier, benzine or other oils, either separately or in combination with one another.

Such tests shall be made of said pigments or combination of such pigments ground in any number of said oils and driers or combinations of said oils and driers. The object of said tests being to determine the relative spreading, working and lasting qualities of such combinations and their effects on coloring materials used with said pigments, ground in oil and driers either alone or in combination with other pigments, oils and driers.

To facilitate the carrying out of the provision of this act, manufacturers and producers of paints and paint pigments shall provide the director of said Bureau of Geology and Mines with a complete list of formulas used in the manufacture of said paints and paint pigments; which formulas shall set forth the percentages and physical characteristics of all ingredients used in the manufacture of said paints or paint pigments. Provided that such information shall not be so published or otherwise used as to indicate the source of such formulas.

Said Bureau of Geology and Mines is directed to publish from time to time the results of said tests showing the relative spreading, working and lasting qualities and the effect on coloring of different combinations of said pigments, driers and oils.

There has been a great deal of discussion of late relative to the availability of the water powers of this State. The legislature would be justified in appropriating funds to carry on an investigation of the water powers of this State, such investigation to be under the supervision of the director of this Bureau.

The act establishing this Bureau should be amended in many respects so that there may be continuity in the work from year to year, and from administration to administration. In order to bring this about I would recommend that the following bill be introduced at the next legislature, and that its enactment be pushed with the greatest possible vigor.

Be it enacted by the General Assembly of the State of Missouri, as follows:

Section 1. That Sections 7501, 7502, 7503, 7509, 7512 and 7515, of the Revised Statutes of the State of Missouri, 1899, and an act entitled "An act to amend section 7502, chapter 110 of the Revised Statutes of 1899, relating to geology and mineralogy, and to enact a new section, relating to the same subject, to be known as 7502a, with an emergency clause," approved March 9, 1901, be and the same are hereby repealed and the following sections, to be known as 7501, 7502, 7503, 7503a, 7509, 7509a, 7509b, 7510a, 7512, 7512a, 7512b, 7512c and 7515, enacted in lieu thereof.

Section 7501. There is hereby created and established, a bureau of "Geology and Mines" for the State of Missouri, which shall be under the direction and in charge of a board of managers which shall consist of the governor, who shall be ex-officio president of the board, and four citizens from the State at large, who shall be appointed by the governor, by and with the consent of the senate, and who shall hold their term of office for one, two, three and four years for the first appointees, respectively, under this act, and thereafter for four years. Not more than two shall be appointed from any one political party.

Section 7502. The board of managers are authorized, as soon as they are organized, to appoint a director of the Bureau, who shall be a person of a competent scientific and practical knowledge of the sciences of geology and mineralogy, and whose headquarters shall be located at such place as may be determined by the board of managers, which director of the Bureau shall also be the state geologist, and said director of the Bureau may appoint such assistants and subordinate assistants and laborers as may be deemed necesary in order to make a thorough scentific, geological and mineralogical survey of the State.

Section 7503. It shall be the duty of the director of the Bureau and his assistants, under the instructions and directions of the board of managers, to carry on, with as much expedition and dispatch as may be consistent with minuteness and accuracy, a thorough geological and mineralogical survey of the State already begun, with a view to determine the order, succession, arrangement, relative position, dip or inclination and comparative magnitude of the several strata of geological formations within this state, and to discover and examine all beds or deposits of mineral contents and fossils, and to determine the various positions, formations and arrangements of the many different ores, clays, rocks, coals, mineral oils, natural gas, mineral and artesian waters and

other mineral substances as may be useful or valuable; also to note carefully the character of the soils and their capacities for agricultural purposes, make examinations of materials suitable for the improvement of highways, and highway construction, make tests of all materials used in building constructions, the growth of timber and other scientific matters that may be of practical importance and interest; and said director of Bureau shall cause to be represented on the map of the State, by colors and other appropriate means, the various areas occupied by the different geological formations in the State, and to mark thereon the localities of the respective beds or deposits of the various mineral substances, and on the completion of the survey, to complete memoirs of the geology and mineralogy of the State, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey.

Section 7503a. It shall be lawful for the director of the Bureau, or for any of his assistants, to enter, examine and inspect any and all lands, mines and machinery belonging thereto at all reasonable times by day or night, and the owner, operator or agent is hereby required to furnish all necessary facilities for such examination and inspection; and if the said owner, agent or operator aforesaid, shall refuse to permit such inspection, or to furnish the necessary facilities for such entry, examination and inspection, the director of the survey, or an assistant, shall file his affidavit setting forth such refusal before the judges of the circuit court in said county in which said mine is situated, either during the term of the court or during vacation, and obtain an order on such owner, agent or operator so refusing as aforesaid, commanding him to permit and furnish such facilities for the inspection of such mine, or to be adjudged to stand in contempt of court and punished accordingly.

Section 7509. It shall be the duty of the board of managers to report to each general assembly the progress and condition of the survey, an accurate account of money spent, and such reports of the director of the survey and his assistants as have been completed, together with all such information as may be deemed necessary and useful.

Section 7509a. The Bureau of Geology and Mines is herewith charged with the compilation of complete statistics of the production of all mines, quarries, cement factories, lime kilns, clay-working plants, and such other mineral, stone or clay products as may be exploited or operated in the State of Missouri.

Section 7509b. All special and regular reports, after having been approved by the board of managers, shall be published by the commissioners of public printing, the cost of same being paid for out of the general appropriation for printing State documents. The director shall also obtain, by requisition on the Secretary of State, all necessary stationery, office supplies, postage, etc., which shall be paid for out of the general fund provided for such purposes.

Section 7510a. There shall be maintained by the Bureau of Geology and Mines, a chemical laboratory for assaying and analyzing ores, rocks, clays, and minerals; and a physical laboratory for testing bricks, stone, terra cotta, sewer pipe, cement, concrete, asphalt, and any other materials that may be used in the construction of buildings or the improvement of public highways. Specimens obtained from lands in Missouri shall be examined free of cost to citizens of Missouri, when properly collected from undeveloped mines and prospects. The person furnishing such samples for examination must first present satisfactory evidence to the director that said samples of rock, clay or ore occur in commercial quantity, and he must also furnish, with the sample, a description by quarter section, township and range, or the location of the land from which said specimen or specimens were obtained.

Section 7512. As full compensation for the members of the board of managers, they shall be allowed five dollars per day and their necessary expenses while attending to the duties assigned them: Provided, however, that the aggregate of compensation paid as salary to all of said board shall not in any one year exceed four hundred dollars. The board shall fix the salary of the director of the Bureau. The director of the Bureau, with the approval of the board, may appoint such regular or temporary assistants as may be needed to carry out the requirements of this law. Their compensation shall be fixed by the board of managers, upon recommendation of the director.

Section 7512a. The board of managers may, during the biennial period expend a sum not to exceed one-half of the general appropriation for the maintenance of the Bureau, in the preparation of county reports, including geologic and topographic maps, or both.

Section 7512b. The board is further authorized to enter into agreements with any county in this State to make such reports, provided one-half of the cost of preparing said reports shall be

guaranteed to be paid by said county, either from the treasury thereof, or from private subscription: Provided, that when a county shall have once been completely surveyed it shall not be surveyed a second time under the provisions of this act. The survey of counties shall be made in the order in which petitions are received from the county courts of such counties as shall guarantee one-half of the expense of said survey.

Section 7512c. Every county in the State shall have authority by or through the county court, or an agent appointed by said court, to enter into a contract with the board of managers of the bureau of geology of mines, binding said county to pay one-half the cost of geological and mineralogical surveys of said counties, or parts thereof, made under the supervision of said board, including the cost of preparing and making reports, geological and topographical maps.

Section 7515. The board of managers shall have the general management of the bureau and have full power to remove the director and appoint his successor when deemed necessary for the good of the work entrusted to him; and the director shall have full control over his assistants, and have power to remove and appoint their successors when deemed necessary.

To protect the public from the operations of corporation, joint stock, co-partnership or individual mining enterprises floating fictitious mining stocks, I would recommend the enactment of a law along the lines of the following bill introduced into the last session of the legislature.

Be it enacted by the General Assembly of the State of Missouri, as follows:

Section 1. Any person who knowingly makes or publishes, in any way whatever, or permits to be so made or published, any book, prospectus, notice, report, statement, exhibit or other publication of or concerning the affairs, financial condition or property of any corporation, joint stock association, co-partnership or individual, which said book, prospectus, notice, report, statement, exhibit or other publication shall contain any statement which is false or wilfully exaggerated, or which is intended to give, or which shall have a tendency to give, a less or greater apparent value to the shares, bonds or property of said corporation, joint stock association, co-partnership or individual, or any part of said shares, bonds or property than said shares, bonds or property, or any part there-

of, shall really and in fact possess, shall be deemed guilty of a felony, and upon conviction thereof shall be imprisoned for not more than ten years or fined not more than ten thousand dollars, or shall suffer both said fine and imprisonment.

Sec. 2. The director of the bureau of geology and mines or one of his duly accredited assistants under his direction, is hereby charged with the investigation of all supposedly fraudulent corporation, joint stock, co-partnership or individual mining enterprises which may be operating, advertising or circulating literature in this state, which may be duly brought to his attention by the attorney-general, or which he may have reason to believe exists from his own knowledge. The attorney-general is authorized to proceed against any such corporation, joint stock company, co-partnership or individual which, after an investigation by the director of the bureau of geology and mines, may be supposed to be violating the provisions of section one (1) of this act.

Sec. 3. All acts and parts of acts in conflict with this act are hereby repealed.

Sec. 4. In the opinion of the general assembly an emergency exists; therefore this act shall take effect and be in force from and after its passage.

In the matter of future investigations to be carried on by this Bureau, I would suggest that a new edition of Wheeler's report on "Clay Deposits" be prepared and published; that the report on "Iron Ores" by Nason be revised and another edition published; and that the report on "Coal Deposits" should also be revised. The preparation and publication of educational bulletins and the collection of specimens of ores, rocks and fossils for the use of the colleges and public schools in this State would be very valuable in increasing the knowledge of the general public relative to our own mineral resources.

It is further suggested that the "General Geology" which I have about two-thirds completed, be finished and published as Vol. X. In addition to this I had in preparation at the close of my administration, a report on "Well Drilling," which was to contain all available data on well borings; and a report on "Chemical Analyses" which was intended to bring together and classify all chemical analyses of Missouri ores, minerals, coals, rocks and clays, published and unpublished. These volumes would be extremely useful to the public, and would serve to preserve much of the data which is now scattered and therefore useless.

I would further suggest that this Bureau arrange an exhibit annually, for the State Fair, and that to this end the director be instructed to co-operate with the secretary of the Board of Agriculture.

The statistics covering the mineral productions of this State, and collected and compiled by the Labor Commissioner, are not only deficient in the field that they cover, but they are also unreliable. The mining statistics now being gathered by the Bureau of Mines and Mine Inspection are incomplete. If the legislation recommended above be enacted, this Bureau will be given complete charge of the collection of the official statistical data covering the mineral production of this State, a step which is of no little importance.

I would further recommend that an increased appropriation be made for topographic mapping, in co-operation with the United States Geological Survey. The topographic maps are not only a necessity for geological work, but they are also an essential for the proper improvement and maintenance of the highways of the State, also in an investigation of the water power resources, these maps will be of a very great service.

The Director of this Bureau has necessarily spent considerable time in the mines in various parts of this State. His attention has been especially directed to the causes of mine accidents, and I wish at this place to quote from the report of Mr. James T. Sheridan, United States Mine Inspector, who makes the following recommendation relative to the employe's liability in case of accidents in mine. I think that the recommendation here made is one which is worthy of the careful consideration of our legislature.

"A large majority of the accidents in coal mines are due to gross negligence of the miner himself—negligence bred from constant familiarity with dangers incident to his vocation."

"The operator is bound by the law to furnish every reasonable protection to his employee by maintaining proper conditions in and about the mine, and it is the duty of the Mine Inspector to see that these conditions are maintained, and if the law be not complied with, to prosecute the operators and bring suit for injunction to suspend operation of the Mine."

"But the employee enjoys immunity from punishment for violation of the law. He may, by gross carelessness or negligence, endanger his own life or person or that of his fellow-workmen with impunity, the only punishment being the suspension of operation of his working place, and at most his discharge."

"If he were amenable to the law for its violation, it is hardly probable that he would act in such wanton manner as now; when free from such restraint."

During the last few years there has been a concerted movement upon the part of some of our State and national officials looking toward the preservation of our natural resources. This movement has been directed most actively toward the reforesting of our cut-over timber lands and the irrigation of our so-called deserts. In this State the reclamation of the swamp land along the Mississippi river is the only thing that has been brought to the attention of our legislature. However, there are thousands of acres of barren, rock-strewn land in the Ozarks which might be reforested if cared for by the State government.

I desire, also to call the attention of the public to the wasteful methods of mining now in vogue in some parts of our State. A conservative estimate shows that in the southwestern part of the State fully fifty per cent of the lead and zinc in the ore bodies being mined, is lost, by being left in the ground through imperfect methods of mining, by the iniquitous leasing system and through crude methods of concentration. Some mines are being worked on a twenty per cent royalty, and in such the operator never attempts to mine ore which will not pay him a profit plus this twenty per cent royalty. In the richest mines, only that which is most easily concentrated is recovered, the remainder finding its way to the chat pile or the sludge pond.

The lead and zinc ores, for which our State is now famous, do not occur in inexhaustible quantities and the deposits should not be plundered to enrich the present generation at the expense of the future. There is perhaps nothing more desirable than that this Bureau should devote some attention to methods of mining and concentration, whereby the ore deposits within the State may be economically and judiciously exploited.

As concerns national policies, I am of the opinion that our government should not encourage the exportation of raw materials, whether it be the fuels or metals; that our enormous deposits of coal, iron, lead, zinc, etc., should be preserved to meet the needs of future generations. The Bureau of Geology and Mines should exercise such influence as it may possess in seeking to prevent any waste of the State's resources, in order that the fountains from which the wealth and prosperity of the State and Nation are obtained, may survive the careless wastefulness of the present overfed generation.

CHAPTER IV.

MINERAL RESOURCES OF MISSOURI.

Complete statistics covering the mineral industry of Missouri are not collected at the present time by any of the departments maintained by the State. Other than the biennial report of the State Geologist there is no publication in which this important information is brought together and tabulated.

The following short resume includes the value of the ores and structural materials produced in 1907 and a brief mention of the geological formations from which they are obtained.

The State Geological Survey cooperated to some extent with the United States Geological Survey in the collection of statistics covering the production of lime, stone, clay, sand, gravel and cement and the values given below are the result of such cooperation. The Bureau of Mines and Mine Inspection collects the statistics covering the production of lead, zinc, coal, iron, barite, tripoli and copper and the values given for these materials are taken from the annual report of that department.

The following table shows the total value of the mineral output for Missouri during 1907:

Lead ore	$9,823 823
Zinc ore	9,056 965
Coal	7,806 125
Clay products	7,342 421
Stone	2,325 611
Lime	877 970
Portland Cement (est.)	3,000 000
Mineral Water (est.)	100 000
Iron ore	220 176
Sand and Gravel	790 974
Tripoli	48 144
Copper	70 187
Barite	292 540
Total	$41,252 936

This is the largest output in the history of the State. The growth has been steady during the past ten years and will undoubtedly continue to increase as the value of the undeveloped resources become better known.

Missouri has a greater variety of valuable mineral deposits than any state in the Mississippi Valley. This fact is due largely to the diversified geological conditions occurring within her boundaries.

ASPHALT.

Extensive deposits of asphaltic sandstone occur in Barton and Vernon counties in the southwestern part of the State. These deposits have never been exploited for the production of asphalt, altho the stone often contains as high as 15% of bituminous material.

The rock has been quarried in a small way at Liberal where it is used for sidewalks and curbing. It is rather soft and when subjected to heavy traffic wears rapidly.

During the past year the City of Carthage experimented with this material as a road metal. Crushed sandstone, containing a high percentage of Asphalt was used as a surfacing material for a short distance on a macadam road in the northwestern part of the city. When examined the surface was very soft and full of ruts. The material, does not seem to have sufficient binding qualities to make a durable wearing surface and unless a suitable binder is added will not withstand heavy traffic.

Geologically, these deposits occur in the Lower Coal Measures. The asphalt is the residuum from the oxidation and evaporation of petroleum which at one time occurred in these beds. The sandstones vary in thickness and in the percentage of asphalt contained.

In the mining district of Newton and Jasper counties, asphalt is frequently encountered in openings in the Mississippian limestone. This "tar," as it is called locally, has apparently seeped downward from the sandstones to its present position. It does not occur, however, in sufficient quantity in this formation to be of commercial value.

BARITE.

According to the report of the State Mine Inspector for 1907, Missouri produced 60,370 tons of barite valued at $292,540. Approximately three fourths of this was mined in Washington county.

These deposits occur almost exclusively in the Cambrian formations, altho a small quantity has been found associated with galena and sphalerite in the coal pockets of Miller county. The more important deposits occur in the Potosi formation in Wash-

ington county. In the central portion of the State barite occurs in the Gasconade, Roubidoux and Jefferson City formations.

The barite is mined through shallow shafts sunk in the residual clay. This mineral, which is commonly associated with galena, occurs in chunks embedded in the clay and in fissures in the dolomite, the latter deposits usually occur directly underneath the residual ore, which at one time undoubtedly occupied an upward extension of the fissure, the limestone having been removed by solution. These fissures often extend to a depth of several hundred feet. In Franklin county they have been mined to a considerable depth for the galena content, altho the "lode," as the barite is called locally, is constantly associated with the galena.

Barite does not occur in the disseminated lead deposits of St. Francois county nor in the lead and zinc deposits of southwest Missouri.

Brief mention of the occurrence of barite is made in the Miller, Morgan and Moniteau county reports and in the report on "The Geology of the Disseminated Lead District of St. Francois County." The last report contains a map showing the productive and worked out areas in the vicinity of Mineral Point, Mo.

BUILDING STONE.

The value of the stone produced in Missouri for 1907 was $2,325,611. The following table shows, in detail, the value of the limestone, granite and sandstone produced, and the different uses of each.

Uses.	Limestone.	Sandstone.	Granite.	Total.
Building and Monumental	$ 538,114	$25,208	$ 60,097	$ 623,415
Paving	2,218	50	15,966	18,234
Curbing	14,104	150		14,254
Flagging	12,699	325		13,024
Rubble	218,827	2,940		221,767
Riprap	152,090	3,600	8,375	164,065
Crushed: Road making	428,261		16,424	444,685
Crushed: Railroad ballast	234,068		32,100	284,158
Crushed: Concrete	418,990		35,448	454,438
Flux	43,612			43,612
Sugar factories	317			317
Miscellaneous	40,627	3,021		43,648
Total	$2,158,917	$35,289	$136,405	$2,325,611

The total value is $166,317 greater than the production in 1906. While the industrial depression affected certain phases of the industry, notably the dimensional trade, it did not affect the output sufficiently to cause a decrease in value of the total production. The granite industry seems to have been the only branch which suffered a decrease in the total output. Both sandstone and limestone show an increase in production. The use of crushed limestone for concrete shows an increase in value of $102,854. This is an increase of approximately 25% and is the largest advance shown by any of the stone industries.

The wide range of geological formations occurring in the State is reflected in a corresponding variety of excellent building stone. Missouri contains inexhaustible quantities of the finest red granite, limestone and sandstone. The industry is as yet largely undeveloped.

The pre-Cambrian igneous rocks occurring in St. Francois, Iron, Madison and other counties of southeastern Missouri, produce the excellent red granite for which this State is noted. Extensive quarries have been opened at Graniteville and Syenite for the production of monumental and building stone. During recent years several crushing plants have been established at different places in the granite district. The crushed granite is unexcelled for use as a road surfacing material and in granitoid walks.

The granite quarries now in operation produce only rough building and monumental stock. The fact that they do not manufacture finished monuments is undoubtedly largely responsible for the comparatively restricted use of this stone in monumental work.

During the past year the Missouri Red Granite Monument Company of St. Louis, has equipped a modern plant for dressing and polishing Missouri granite. The Graniteville stone is used exclusively by this firm.

The various sedimentary formations produce a variety of limestones capable of being used for practically all constructional purposes.

The Burlington formation furnishes the excellent limestone quarried so extensively at Carthage. This stone excels any produced in the middle west in color, strength and durability. The quarries at Phoenix, Ash Grove and Hannibal are in the same formation.

The limestone of the St. Louis formation furnishes practically all the rubble and crushed stone used in the city of St. Louis.

The Kimmswick limestone exposed at Cape Girardeau has been metamorphosed to a crystalline marble. It furnishes one of the finest building stone in the State.

The Coal Measures underlying the northwestern part of the State, contain a number of heavy ledges of limestone. They are, as a rule, irregularly bedded, poor in color and so badly broken by joints as to be unsuitable for dimensional purposes. They furnish, however, excellent stone for crushing and rubble, being extensively quarried in the vicinity of Kansas City and St. Joseph for these purposes.

The Cambrian formations occupying the south central portion of the State consist almost exclusively of dolomite. The different formations do not contain suitable material for cut stone and the present production, which is comparatively small, consists largely of rubble with some crushed stone. In the southeastern part of the State, certain ledges in these formations have been metamorphosed to a crystalline marble. These beds have been exploited to some extent in the past but are not being worked at present.

The heavy ledges of sandstone occurring in the Coal Measures at Warrensburg and Miami are quarried extensively for dimensional stone. These quarries produce the greater portion of the sandstone quarried in the State for building purposes.

One quarry has been opened in the AuxVasse sandstone south of Ste. Genevieve. This ledge was quarried extensively a number of years ago.

Detailed information concerning the quality of the stone obtained from the various geological formations occurring in the State is given in Vol. 11, 2nd series of the reports of this Bureau.

CLAY PRODUCTS.

Missouri stands seventh among the states in the value of her clay products. The total output in 1907 was valued at $7,242,421 which is approximately equal to the total value of the coal mined in the state. In 1906 the clay products were valued at $6,696,275. There was a total increase in value of $546,146 during 1907 in spite of the depressed condition of the building industries. The following table gives the value of the various clay products for 1907:

Common brick	$1,844,255
Vitrified brick	462,841
Front brick	387,456
Fancy brick	83,698
Fire brick	1,684,204
Drain tile	72,816
Sewer pipe	1,582,080
Hollow building tile	42,678
Terra Cotta, fireproofing, stove lining, etc	885,871
Miscellaneous	175,846
Pottery Products	78,187
Clay mined and sold	443,553
Total	$7,842,421

The manufacture of common building brick is the most important clay industry in the State. Fire brick is second, while sewer pipe ranks third in value. The combined output of the three industries equals 65% of the total value of the clay products. Missouri manufactures approximately one-eighth of the fire brick and one tenth of the sewer pipe produced in the United States.

The clay used in the manufacture of common brick is derived largely from the extensive deposits of loess occurring along the Missouri and Mississippi rivers. These deposits vary from 10 to 150 feet in thickness and extend from the Iowa state line to Cape Girardeau.

The clays and shales used in the manufacture of sewer pipe and fire brick are derived almost exclusively from the Coal Measures which underlie the greater portion of northwest Missouri and the northern half of St. Louis county. This series is composed largely of shales which vary widely in chemical and physical properties. The supply is inexhaustible and many of the beds have never been developed.

The deposits of china clay or kaolin occurring in southeastern Missouri are not being worked extensively at the present time. These deposits are almost free from iron but are quite siliceous. With proper treatment an excellent clay free from injurious constituents can be obtained. There is no apparent reason why this industry should not become of much greater importance.

COAL.

According to the report of the State Mine Inspector for 1907, Missouri produced 4,355,494 tons of coal valued at $7,306,125. The following table shows the production and value by counties:

County.	Tons.	Value.
Adair	584,871	$866,334
Audrain	36,629	65,687
Barton	191,106	288,281
Bates	166,512	272,899
Benton	8,106	6,212
Boone	35,495	65,986
Caldwell	11,656	23,557
Callaway	34,748	66,583
Carroll	4,850	14,067
Cass	8,400	6,800
Chariton	36,474	68,808
Clay	40,590	75,092
Cole	2,401	4,802
Dade	1,912	8,346
Grundy	11,040	27,269
Henry	166,928	308,644
Howard	18,456	25,599
Johnson	66,408	109,706
Lafayette	712,981	1,320,246
Lewis	210	525
Linn	124,068	268,179
Livingston	2,270	4,096
Macon	1,159,288	1,650,065
Moniteau	8,552	8,880
Montgomery	2,990	7,475
Morgan	2,640	6,402
Nodaway	120	450
Platte	259,849	587,878
Putnam	58,999	116,410
Ralls	16,768	30,101
Randolph	97,702	144,685
Ray	349,180	666,371
St. Clair	2,360	5,060
Saline	845	2,112
Schuyler	4,840	9,195
Sullivan	3,000	7,700
Vernon	142,810	221,194
Total	4,355,494	$7,306,125

The Coal Measures occupy approximately 23,000 square miles of the northwestern half of the state. The total thickness of the series which consists largely of shales, limestones and sandstones is approximately 2,000 feet. The formation is separated into the upper and lower Coal Measures by the Bethany Falls limestone. This formation is easily recognized and outcrops along an irregular line extending a little east of north from the western edge of Cass county to the Iowa state line.

The Lower Coal Measures from which practically all the coal is produced has a maximum thickness of 800 feet and underlies an area of approximately 15,000 square miles. The coal beds occurring in this portion of the formation vary from 2 to 5 feet in thickness.

The Upper Coal Measures, which is approximately 1,200 feet in thickness, does not contain known coal beds of importance. Several beds from six inches to one foot thick have been encountered in drilling. A small mine has been opened in Nodaway county on a vein varying from 12 to 18 inches in thickness.

Development work has been actively carried on in several areas north of the Missouri river. During the past year a five foot bed was encountered near the Mercer county line at a depth of 500 feet. A similar bed has been discovered in the eastern part of Harrison county. It is probable that this area will form one of Missouri's most productive coal fields. At present, practically no coal is being produced from the Lower Coal Measures where this series is overlain by the upper coal measures. There is no apparent reason for this lack of production other than the depth to which shafts must be sunk in order to penetrate the coal seams. Drilling in portions of this area has shown workable coal seams in the Lower Coal Measures.

At Leavenworth, Kansas, coal is being hoisted from a depth of 700 feet. This coal which is obtained from the Lower Coal Measures, is mined on the Missouri side of the river. The seam probably underlies a large part of Platte county.

COBALT AND NICKEL.

Missouri is the only state in the union producing nickel and cobalt from native ores. The entire output at the present time comes from the mines near Fredericktown in Madison county. Formerly the mines at Mine LaMotte produced cobalt and nickel sulphides which were smelted to a matte and shipped east to be

refined. Small quantities of these sulphides occur associated with the disseminated lead deposits of the Flat River area. They do not however, occur in sufficient quantity to be of commercial value.

The ore bodies in the vicinity of Fredericktown occur in the upper beds of the LaMotte sandstone and in the lower portion of the Bonneterre dolomite. The ore consists of a mixture of lead, copper, cobalt, nickel and iron sulphides.

During the past biennial period the North American Lead Company has erected a large refining plant for the separation of these metals. The process is largely electrolytic and is being operated successfully on a commercial scale. The company is producing electrolitic copper and nickel, cobalt, oxide and lead concentrates.

The Bureau has never investigated these ore bodies in detail. Similar geological conditions occur over a considerable area between Fredericktown and Mine LaMotte and it is possible that the deposits are more extensive than supposed at present. A complete survey of the area should be made in order, if possible, to outline the relations of the ore bodies to the different geological formations. Such work would serve to point out the favorable areas for prospecting.

COPPER.

Small amounts of copper have been produced in this State intermittently during the past 50 years. During the past two years the North America Lead Company of Fredericktown, Mo., has developed the extensive bodies of copper, cobalt, nickel and lead sulphides occurring in the LaMotte sandstone and is now producing each of these metals. This is the only company producing copper in Missouri at the present time.

Geologically, the deposits of copper found in the state occur in the Cambrian and pre-Cambrian formations of the Ozark region. The only deposit in the pre-Cambrian that has been exploited to any extent occurs near Eminence in Shannon county, where a shaft has been sunk over a hundred feet upon a small fissure vein in the porphyry. The vein contains the carbonates of copper, malachite and asurite, and chalcopyrite. These minerals seem to have been introduced into the fissure by solutions which have leached the overlying Cambrian limestone. Considerable copper carbonate occurs in the latter formation.

Copper frequently occurs associated with the iron ores in the

Ozark region. As these deposits are worked in depth, copper carbonates and sulphides are often encountered. This association of the copper has not been investigated extensively and these deposits are not being worked at the present time.

At the mine of the Copper Mountain Copper Company, four miles southeast of Sullivan, Missouri, copper carbonates and sulphides occur associated with iron ore and clay. This company has completed approximately 800 feet of drifting, most of which is in ore. A small smelter and mill was erected a few years ago and some copper was smelted. The plant has not been in operation during the past year. The property has not been developed in depth to the water level and the extent of the ore is not known.

IRON ORE.

According to the State Mine Inspector's report, iron ore was produced in sixteen counties during 1907. The total output was 120,889 tons valued at $250,556. The following table shows the amount and value of the ore produced in each county:

County.	Tons.	Value.
Butler	9,212	$18,424
Carter	280	700
Christian	2,640	5,480
Cole	714	1,785
Crawford	37,017	74,082
Franklin	18,265	36,530
Greene	5,720	11,440
Howell	11,580	26,055
Lawrence	80	160
Madison	90	216
Miller	840	1,890
Newton	280	560
Phelps	8,125	15,284
Shannon	10,000	22,000
Stoddard	1,800	4,000
Wayne	720	1,620
Total	107,363	$220,176

The above table does not indicate a production for St. Francois county, altho considerable ore was shipped from Iron Mountain. This ore was obtained by washing the old dumps.

Crawford and Franklin counties are the largest producers. Reports received from Mr. J. E. Burton of St. Louis indicate a much larger production than is accredited to Wayne county. Prospecting has been actively carried on in this county during the past two years and the following mines have been opened. A number of these have produced several thousand tons of ore.

Higgins Mine	S. E. ¼ Sec. 5, T. 29, R. 7
Yount & Kelsall	S. E. ¼ Sec. 7, T. 29, R. 7
Christman Mine	S. W. ¼ Sec. 28, T. 28, R. 5
Lundy & Harness	S. W. ¼ Sec. 34, T. 28, R. 5
Inda Mine	N. W. ¼ Sec. 8, T. 28, R. 6
Juda Mine	S. W. ¼ Sec. 35, T. 28, R. 5
Zippi Mine	S. W. ¼ Sec. 27, T. 29, R. 6
Burton Mine	S. W. ¼ Sec. 21, T. 29, R. 6
Myers Mine	N. W. ¼ Sec. 21, T. 29, R. 6
Long Mine	S. W. ¼ Sec. 5, T. 29, R. 6
Van Dolson	
Janase Mine	

The Mississippi Valley Iron and Furnace Company recently incorporated in Missouri has acquired several thousand acres of iron land in the southeastern part of the state. The company contemplate erecting a furnace and opening a number of new ore bodies.

Deposits of iron ores are known to occur in forty-eight counties in the State. The present production is obtained almost exclusively from the deposits occurring in the Cambrian formations of central and southeast Missouri and from the deposits occurring in the residual clay overlying the Burlington limestone of southwest Missouri.

LEAD AND ZINC.

The total value of the lead and zinc ores produced in Missouri in 1907, according to the State Mine Inspector, was $18,880,788. The total production of lead ore was 151,294 tons valued at $9,823,823, while the total production of zinc ore was 225,391 tons valued at $9,056,963.

The following table gives the amount and value of the lead and zinc ores by counties.

COUNTY	LEAD		ZINC	
	Tons	Value	Tons	Value
Benton	2	$ 158.00		
Camden	29	2,884.00		
Christian	1	74.00		
Cole	296	21,312.00	146	$ 6,424
Dade			58	2,465
Franklin	400.75	28,005.00		
Greene	244	17,832.00	800	36,782
Jasper	347.42	2,351,462.00	188,874	7,917,913
Jefferson	118 ¾	7,278.00	1,095	15,330
Lawrence	411 ½	28,877.00	12,985	406,357
Madison	11,188 ½	682,310.00		
Miller	37	2,701.00		
Moniteau	360	26,204.00	61	1,890
Morgan	52	3,744.00	78	3,354
Newton	2,791	207,005.00	21,285	655,890
Polk	4 ½	315.00		
St. Francois	90,324	6,356,368.00		
Taney	120	8,400.00	96	3,744
Washington	11,188	77,400.00	510	7,496
Webster	7	476.00		
Wright	22	1,518.00		
	151,294	$9,828,828.00	225,819	$9,056,965

It is worthy of note that for the first time Missouri leads all other states in the value of the lead ores produced. Idaho formerly surpassed Missouri.

The low price of pig lead resulted in a curtailed production during the latter part of 1907 and the early part of 1908. During this period a number of the important mines of Southeast Missouri were closed or were operated with a much reduced force. During the last half of 1908 the mines were operated at full capacity.

The milling capacity of the Flat River district has been greatly increased during the past two years. In 1907, the Federal Lead Company completed the erection of a large concentrating plant having a capacity of 3,000 tons per day. The Doe Run Lead Company remodeled the plant located on the old Columbia Lead Com-

pany's property and are now erecting a large plant west of Elvins. This mill will have a capacity of 1,500 tons per day.

Very little prospecting in new territory has been carried on during this period. At the present time no new properties are being drilled. Practically no new territory has been discovered, altho the Federal Lead Company has greatly increased its ore reserves by prospecting in the vicinity of its developed mines.

Development in the Joplin district have been largely confined to the sheet ground. Extensive deposits of these low grade ores are being opened and the percentage of the total output derived from these deeper ore bodies is continually increasing.

The low price of ore maintained during the greater part of 1907 and 1908, caused many mines to lie dormant during the greater portion of the period. With the present price of $40 per ton these are again being opened up.

While many important strikes were made in the developed territory, there was a lack of prospecting in the outlying districts. Jasper, Newton and Lawrence counties have hundreds of square miles of very favorable territory that has never been prospected.

The most important development in the western district during the past biennial period was the discovery of rich deposits of ore at Miami, Oklahoma, in 1907. While not in this state, the same general geological conditions apparently occur north of Neck City and Alba and the relation of these ore bodies has an important bearing on the possible extension of the productive area in this State.

Prospecting has been continued intermittently throughout the central Ozark region. Scattered deposits are known to occur in almost every county in the southern portion of the state. A number of these have given evidence of considerable promise.

Northwest of St. Clair in Franklin county, prospecting and development work have been carried on at the Enterprise and Zark properties.

The Enterprise mine has a drift of several hundred feet along a small fault. The fissure which is filled with galena and barite, has been mined to a depth of 75 feet. A small mill will be erected upon the property. The company has approximately 1,500 tons of mill dirt on the dump ready for concentration.

At the Zark mine, a drift approximately 100 feet in length has been driven along a gnarled ledge of flint which carries approximately 3% of galena. The ore occupies small fissures and

openings in the rock. Near the north end of the property, a shaft has been sunk on a breccia carrying lead, zinc and barite. This ore will apparently run 5 or 6%. Very little development work other than sinking the shaft has been done at this point. The property is equipped with a small mill.

According to Hon. J. R. Dalby of Sedalia, a shaft sunk at Otterville, Cooper county, has encountered from 10 to 15 feet of good ore at a depth of 100 feet. South of Sedalia in Pettis county, ore has been encountered at a depth of 85 feet. The ore body is said to have a thickness of from 15 to 20 feet and averages from 8 to 10% zinc. A 75 ton mill has recently been erected on this property.

Prospecting has continued with increased vigor south of Newburg in Phelps county. Some ore has been shipped but the work has been largely devoted to prospecting. The ore occurs in the clay and in a brecciated layer of flint occurring in the Gasconade limestone.

LIME.

During 1907 Missouri produced 190,300 tons of lime valued at $877,970. The value for 1906 was $790,285. The increase of 1907 over 1906 was $87,785 or 11%. The following table shows the increase in value of the lime produced in the State during the past ten years:

1898	$297,401
1899	383,549
1900	398,010
1901	546,549
1902	515,780
1903	641,948
1904	597,258
1905	712,950
1906	790,285
1907	877,970

Missouri stands fourth among the states in the value of lime produced, being surpassed by Maine, Ohio and Pennsylvania.

It is evident from the large increase in production during the past few years that the extensive use of Portland cement in building construction has not injured the lime industry.

Approximately 1-10 of the lime burned in the United States

is used as a fertilizer. Large quantities are also used by sugar factories, steel works, glass plants, smelters, chemical works, soap factories and paper mills. As yet, only a small proportion of the lime manufactured in this state is used in any of the above industries.

During the past biennial period, the Rogers White Lime Company abandoned its kiln at Republic, Mo., and erected a modern plant at Wilson creek in Greene county. Another notable improvement in the industry has been the installation of a hydrating plant by the Hannibal Lime Company of Hannibal. This is the second hydrating plant installed in the state, the first having been erected several years ago by the Ash Grove White Lime Company at Ash Grove.

Missouri produces high calcium limes exclusively. The entire product is manufactured from stone obtained from the Burlington, Kimmswick and Spergen formations. The Burlington produces over one-half of the total output.

This department recently published a volume devoted to the Lime and Cement Resources of the State. It outlines the general character of the various geological formations suitable for the manufacture of high grade limes and describes the character of the different limes being produced in the State.

MANGANESE.

Missouri does not produce ores of manganese at the present time.

A number of deposits of iron ore in the southern part of the State are known to contain relatively high percentages of manganese. During the past year one of these deposits has been developed in Shannon county. The ore shipped, however did not contain sufficient manganese to prove of value and the deposit is not being worked at present.

MINERAL PAINTS.

During 1907, Missouri produced 14,625 short tons of mineral paint, valued at $1,670,052.

This value includes the production of zinc-lead, sublimed white lead, sublimed blue lead, and litharge. The amount of barite, iron ore and ground limestone used for this purpose is not known and is therefore not included in the above.

As the value of the raw material used in the manufacture of these pigments is included under the production of lead and zinc ores, this item is not added to the total value of our mineral resources.

The industry is one of importance to our mining regions as it provides an outlet for approximately one-tenth of the lead ores produced in the State.

MINERAL WATERS.

Missouri is abundantly supplied with a great variety of mineral waters, having excellent medicinal properties. The output is valued at approximately $100,000 annually. This is but a small proportion of the water that could be sold if properly advertised.

At the present time the following springs and wells are marketing waters:

Belcher Artesian Well, St. Louis, Mo.
Blue Lick Spring, Blue Lick, Mo.
Sweet Springs, Sweet Springs, Mo.
McAllister Spring, McAllister, Mo.
Eldorado Springs, Eldorado, Mo.
Lithium Spring, Central Park, Mo.
Lithium and Soda Springs, Excelsior Springs, Mo.
B. B. Springs, Bowling Green, Mo.
American Springs, St. Louis, Mo.
Aqua Vitae Spring, Canton, Mo.
Chalybeate Spring, Mooresville, Mo.
Lithia Spring, Mt. Washington, Mo.

The above are only a few of the springs occurring in the State. The waters sold include Chalybeate, Litha, Muriatic, Sulpho Saline and Alkaline. Probably no state in the middle west has a greater variety of waters which possess medical properties. As the value of the different springs become better known, the output will rapidly increase.

The Ozark region has abundant large springs of pure water. These are not extensively utilized at present for domestic purposes.

NICKEL (See Cobalt).

PORTLAND CEMENT.

Missouri produced approximately 3,000,000 barrels of Portland cement during 1907. The development of the industry in the State has been very rapid, and the output will be greatly increased during the next few years. Two new plants have been erected during the past biennial period. The Kansas City Portland Cement Company completed its plant north of Independence during 1907. The Continental Portland Cement Company of St. Louis has recently completed a plant southwest of the city. The maximum capacity of the four plants operated in the State at present is approximately 20,000 bbls. per day.

The Missouri Portland Cement Company of Kansas City, Mo., contemplated building a 2,500 bbl. plant at Iatan during the coming year. The Cape Girardeau Portland Cement Company of Cape Girardeau has also completed plans for the erection of a plant south of that city.

Missouri is supplied with inexhaustible quantities of the raw materials necessary for the manufacture of Portland cement. As shown in the recent report published by this department covering the Lime and Cement Resources of Missouri, suitable limestone occurs in the Trenton, Burlington, St. Louis and Coal Measure formations.

The eastern and northern portions of the State are underlain by these formations. At present the Burlington and St. Louis limestones of the Mississippian and the Iola limestone of the Pennsylvanian are being used. The Cape Girardeau plant will use the lower Trenton limestone.

The shales which are being used belong to the Devonian and Coal Measures. The Atlas Cement Plant at Hannibal is using the Hamilton shales, while the St. Louis Portland Cement Company and the Kansas City Portland Cement Company are using the Coal Measure shales. Both formations contain inexhaustible quantities of good shale. The Continental Portland Cement Company of St. Louis is using loess clay.

Within a few years Missouri will undoubtedly lead the states of the Mississippi Valley in the production of Portland cement.

OIL AND GAS.

The recent extensive development of the oil fields of Illinois, as well as the enormous production of oil and gas in Oklahoma and Kansas have combined to direct the attention of producers to the territory lying between these fields.

During the past biennial period, thousands of acres of land have been leased throughout the State and wells have been drilled in St. Louis, St. Charles, Dent, Phelps, Knox, Johnson and Mercer counties. A number of these are located in territory that does not possess the geological conditions necessary for the accumulation of commercial pools of either fuel.

The major portion of the oil and gas produced in Illinois, Oklahoma and Kansas is obtained from the Coal Measures. Similar beds underlie the northwestern part of this State and it is this area which offers the greatest promise of finding oil and gas. The Coal Measures have a thickness of approximately 2,000 feet.

While this region has not been prospected extensively, gas has been encountered in a number of wells drilled at several places. Shallow wells north of Warrensburg in Johnson county, have encountered gas at a depth of from 90 to 300 feet, and when the water is pumped out of these wells, they burn continuously. The gas, however, is not under sufficient pressure to cause a flow when the water is allowed to rise in the well.

A flow of gas is also reported at Lathrop in Clinton county. The well has a depth of 200 feet. Recently a small flow was encountered while drilling near Cameron. At Holt, in Clay county, there is also a shallow well showing gas.

At Belton in Cass county, a number of wells have encountered some oil in the sandstone of the Coal Measures. A production of several bbls. per day was reported from this area for a short time but at present they are not producing.

A number of wells drilled in St. Louis have encountered gas at various depths. The following paragraphs quoted from the biennial report of this Bureau to the 43rd General Assembly, describes the most important flow yet encountered in that area.

"In 1903, the Welle Boettles Bakery Company of St. Louis struck natural gas in a well which they drilled at their plant on Vandeventer avenue and Forest Park boulevard. The gas was struck at a depth of 670 feet and is reported to have furnished a pressure of 250 pounds. Since then two additional wells have been

sunk to a depth of 1,000 feet without encountering anything but salt water. In the third well traces of oil were found at a depth of 280, feet and gas at 675 feet."

"The gas from the first well has been used to heat three furnaces, or six ovens day and night."

There is very little probability of encountering either gas or petroleum in large amounts in the small basin of Carboniferous rocks, upon which St. Louis is located. Other wells of small pressure may be found, but the structure of the region combined with the restricted nature of the basin argues against finding either petroleum or gas in large quantities."

This Bureau has not completed a detailed geological survey of the area underlain by the Coal Measures and until this work is done it will not be possible to outline the most favorable area for prospecting.

SAND AND GRAVEL.

The value of the sand and gravel produced in 1907 was $790,-974. The following table shows the output and value of the sand and gravel used for different purposes.

	Quantity (Short Tons)	Value
Glass Sand	188,488	$ 92,898
Moulding Sand	48,814	32,668
Building Sand	1,890,822	485,441
Fire Sand	15,788	8,979
Engine Sand	84,500	6,808
Furnace Sand	15,000	7,500
Sand (Misc. uses)	48,760	27,051
Gravel	874,468	179,684
	3,075,280	$790,974

The above table is incomplete in that it does not include the sand and gravel used for concrete and road metal in many of the smaller towns and villages of the State. The total production of the State will easily exceed one million dollars in value.

The glass sand is produced exclusively from the St. Peter's sandstone which occupies a narrow belt in the eastern part of the State. The sandstone is quarried extensively at Klondike, Pacific and Crystal City. The deposits are easily worked and produce an excellent grade of white sand which is used in the manu-

facture of plate glass. Care must be taken in quarrying not to include those portions of the sandstone containing iron.

The greater portion of the common building sand and gravel is obtained by dredging from the Mississippi and Missouri rivers and their larger tributaries.

In the northern portion of the State small deposits of sand and gravel of glacial origin are worked for local use. In Bates and Vernon counties sand is obtained from the weathered portions of ledges of sandstone belonging to the Lower Coal Measures.

TRIPOLI.

According to the report of the State Mine Inspector, Missouri produced $70,144 worth of tripoli in 1907. The value is the largest yet reported for any single year.

The main deposits, which are controlled by one company, occur within a radius of ten miles of Seneca, Newton county. They consist of partially decomposed flint which has become very porous through the abstraction of the soluble silica. The value of the deposit depends upon the extent to which decomposition has taken place. Where the tripoli is soft and easily pulverized, it is ground and used for polishing powder. Where decomposition has not gone so far and the material is not easily broken, the tripoli is used exclusively for the manufacture of filters.

The deposits occur near the surface of the ground and are generally overlain with red clay. They vary from small boulders embedded in the clay to solid ledges 20 feet in thickness. In the thicker beds the upper and lower portions can ordinarily only be used for ground tripoli.

Decomposed boulders of chert having the same characteristics as the tripoli at Seneca occur in other portions of south Missouri. These are not being exploited at the present time and have but little value. Ordinarily they do not have the unform texture shown by the Seneca tripoli.

ZINC (See Lead.)

FINANCIAL STATEMENT—1907-08.

(From State Auditor.)

SUPPORT APPROPRIATION—1907.

Buckley, E. R.	$3,449 81
Boyd, J.	24 50
Buehler, H. A.	975 24
Barnes Crosby Co.	239 66
Crane, G. W.	808 70
Cottey, L. F.	64 04
Cooke, G. T.	16 25
Ellis, J. R.	54 45
Gahrtz, Frank	613 40
Grover, H.	25 00
Gatch, E. S.	30 20
Gast, Aug. Bank Note & Lith. Co.	116 96
Hughes, V. H.	344 28
Gottschalk, V. H.	468 13
Long, Edw. (postage)	175 00
Moore, Ellis	14 00
Mining News Co.	93 00
Mix, W. B.	67 50
Morse, Edw.	187 64
Mound City Eng. Co.	139 08
McLean, Chas.	28 50
Rowley, R. R.	268 30
Reiss, E. F.	32 50
Snyder, B. J.	50 00
Snyder, W. H.	36 50
Shepard, E. M.	204 48
Strobach, (Miss) L. J.	440 00
Stephens, Hugh, Printing Co.	729 69
Stromme, O. U.	474 89
Spaulding Sta. Co.	99 35
Wood, C. R.	172 84
Wheelright, O. W.	355 97
Total	$10,799 86

SUPPORT APPROPRIATION—1908.

Buckley, E. R.	$1,884 91
Buehler, H. A.	2,270 50
Cornwall, Mrs. E. (postage)	200 00
Cottey, L. F.	18 70
Gahrtz, Frank	520 75
Gatch, Elias S.	47 82
Graham Paper Co.	392 48
McCaw (Mrs.), W. J.	212 00
Marbut, C. F.	102 90
Morse, Edw.	175 00
Mound City Eng. Co.	160 83
Small (Mrs.), J. C.	61 00
Stephens, Hugh	18 55
Stromme, O. U.	255 07
Shepard, E. M.	142 32
Seltzer, A. J.	40 00
Strobach (Miss), L. J.	40 00
Stephens, Hugh, Printing Co.	2,090 26
Jones & Cleino.	30 00
Whitner, C. L.	55 73
Total	$8,768 82

LABORATORIES, TOPOGRAPHY, ETC., 1907.

Anderson, C. G.	$2,500 71
Buckley, E. R.	1,053 45
Cunningham, E.	8 25
Ellis, J. R.	185 48
Hawkins, R. H.	9 25
Harris, A.	10 00
Henry Heil Chem. Co.	170 37
Lilly, Ira	23 00
Reese, E. F.	57 00
Roberty, J. N.	119 15
Snyder, W. H.	12 25
Smith, A. A.	82 40
Wilson, Elber	16 83
Total	$4,268 35

LABORATORIES, TOPOGRAPHY, ETC., 1908.

Anderson, C. G	$1,449 26
Baker, H. W	575 58
Buehler, H. A	59 47
Baker, J. T., Chem. Co	40 44
Buxton & Skinner Sta. Co	1,058 00
Eimer & Amend	292 27
Gast, Aug., Bank Note & Lith. Co	550 00
Gale, Thos.	161 90
Heil, Henry	92 76
Lilly, Ira	22 25
Mound City Eng. Co	408 33
Roberty, J. N	28 50
Scruggs, Vandervoort & Barney	38 00
Spilman, J. A	185 61
Scott, J. W	38 40
Illnski, A. X	17 50
Mathews Northrup Works	350 00
Total	$5,368 27

V

MISSOURI BUREAU OF GEOLOGY AND MINES.

H. A. BUEHLER, Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

TO THE

Forty-Sixth General Assembly.

THE HUGH STEPHENS PRINTING COMPANY,
JEFFERSON CITY, MO.

TABLE OF CONTENTS.

BOARD OF MANAGERS.

His Excellency, Herbert S. Hadley, Governor of Missouri, Ex-Officio President of the Board, Jefferson City.

Hon. Philip N. Moore, Vice President, St. Louis.

Hon. S. Duffield Mitchell, Secretary, Carthage.

Hon. John H. Bovard, Kansas City.

Hon. Elias S. Gatch, St. Louis.

LETTER OF TRANSMITTAL.

To the President, Governor Herbert S. Hadley and the Honorable Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to submit a report on the work of the Bureau of Geology and Mines for the years 1909 and 1910.

It is my pleasure to acknowledge to the members of the Board my appreciation of the deep interest which they have manifested in the work, and also to acknowledge the hearty co-operation extended the survey by citizens, mining companies, real estate firms and the Bureau of Mines and Mine Inspection. Information, often of a confidential character, has been given us whenever requested and the entire staff has been received most cordially in all parts of the State.

Respectfully yours,
H. A. BUEHLER, State Geologist.

CHAPTER I.

WORK OF THE BUREAU OF GEOLOGY AND MINES DURING 1909 AND 1910

The work of the Bureau of Geology and Mines during the past biennial period has dealt chiefly with applied geology. Each of the investigations undertaken has had as its object the determination of those geologic factors which may have a bearing on the development of the mineral resources of the regions surveyed.

It is strictly the province of the geologist to study and describe the natural processes through which the various ores, clays, rocks, coal and other mineral resources have been formed into commercial deposits. These deposits are not accidental occurrences, but are invariably associated with certain geological features which, when explained, serve as the most valuable guides in mining and prospecting.

The activities of the Bureau touch almost every phase of the mining, clay working and quarrying industries and through its reports and correspondence it is actively engaged in pointing out the geologic features of economic value in each mining area. Each investigation has for its object either the development of one of our mineral resources, or the description of the geology and mineral resources of some particular area.

The value of the work increases in proportion to the completeness and detail with which it is executed. A study of a single iron mine is chiefly of local value; but a complete study of all the iron mines of the State results in a comparison of deposits and geologic conditions which increases the value of the work many times. One coal analysis is of value in indicating the heat units of a particular bed, but complete analyses covering the various mining districts, indicate the comparative value of the different beds mined within the State. The same is true of topographic surveys. The value of one topographic map is largely local, but a series of such maps covering a mining district or a river system affords data upon which State-wide problems may be based.

Because of this comparative importance of complete information covering any single series of deposits, or special areas, the

work of the Department is usually restricted to special investigations and county mapping, the rapidity with which the results become available depending entirely upon the appropriation received.

The following men have been employed permanently on the Bureau's Staff during the greater part of the past biennial period:

H. A. Buehler, State Geologist.
G. W. Crane, Geologist.
V. H. Hughes, Geologist.
F. C. Greene, Geologist.
John Bodman, Assistant Geologist.
Wallace Lee, Assistant Geologist.
A. X. Illinski, Chemist.

In addition to the above, a number of assistants have been employed for special investigations or for the summer field season. Mr. Henry Hinds has also been detailed by the United States Geological Survey for co-operative work in the Missouri coal fields.

Mr. J. B. Campbell, Clerk, and W. E. Morse, Janitor, have been employed at the office.

The topographic branch has been under the direct supervision of Mr. W. H. Herron, of the United States Geological Survey, Geographer for the Central district. Under his direction the Federal topographic and level parties have carried on the topographic mapping in the areas designated by the State Bureau.

CO-OPERATION.

During the past biennial period the Survey has enjoyed greater co-operation with the United States Geological Survey than ever before. Such co-operation is now carried on: (1) in the collection of mineral statistics; (2) in the collection of data covering deep drilling; (3) in the investigations covering the coals and Coal Measures; and (4) in topographic mapping.

Under the provisions of each agreement the Federal Bureau contributes one-half of the field expenses; making available for each co-operative investigation, double the fund allotted by the State. The State usually benefits also through obtaining trained men from the Federal Survey under whose supervision the work is carried out.

During the past biennial period the Federal Survey spent approximately $11,000 in such co-operative work in Missouri.

Since the establishment of the Federal Bureau of Mines a co-operative agreement has been entered into whereby that Bureau analyzes and tests all samples of coal collected by the State Survey.

GEOLOGIC INVESTIGATIONS.

During the past biennial period the Bureau has made a study of, and has in preparation reports on; (1) the coal deposits, (2) the iron ores, (3) lead and zinc deposits of the Aurora area, (4) the geology and structural materials of Jackson county, (5) the geology of Phelps county, and (6) ore deposits of the southern Ozark region (reconnaissance).

In conjunction with the investigations covering the coal deposits, work has also been carried on in northwest Missouri for the purpose of outlining those geologic features favorable for the occurrence of oil and gas.

COAL.

The Coal Measures underlie approximately 25,000 square miles of the northern and western portions of the State, including wholly or in large part 45 counties. In value, the output of the coal mines ranks next to the output of lead and of zinc.

Because of the great area underlain by these formations and the consequent possibilities of more extensive development as well as the general want of information concerning the position which the coal seams occupy in the Coal Measures formations, the Bureau is making a detailed study of the coal mining camps, and of the formations in which the various coal seams occur. The investigation is being carried on in co-operation with the United States Geological Survey, the cost of all field operations being shared equally by the two Departments. The complete results are available to both Surveys.

The work has been chiefly economic, and in general the following lines of investigation have been followed:

(1) A study of the stratigraphy of the Coal Measures:

(2) A study of the present mining camps.

(3) A study of the extent of our known productive veins and the possible location of new fields.

(4) A study of the fuel values of our minable coals.

(5) The determination of the depth to which the Coal Measures extend in each county.

A detailed study of the stratigraphy of the Coal Measures is essential to a proper knowledge of the occurrence of our coals. These formations have a total thickness of 2,000 feet, although the coal beds themselves comprises less than 25 feet or about 1-100 of the entire thickness. By a sufficiently detailed study, each of the

coal seams occurring in Missouri can be placed in the succession of formations and its relative position to the other coal seams be shown. Those portions of the formations in which coal does not occur can also be indicated and the approximate depth at which the productive Coal Measures may be encountered in each county can be determined.

In studying the present mining camps special attention has been given to the thickness and general nature of the various seams, while the occurrence of partings, faults, "horses" and clay seams, which materially affect mining operations, have also been observed. In each district the character of the floor and roof have been noted, and data collected on the entire succession of formations overlying the coal. This phase of the work has a direct bearing on the cost of mining and on the system which may be employed in extracting the coal. Where a strong roof is present, the long wall method of mining may be used. Through this method virtually all the coal may be taken from the ground, while under the room and pillar method from 25 to 50 per cent is left in stumps and pillars.

Through field observation and a study of drill records, the extent of the known seams is being determined and the areas in which unknown seams may occur are being outlined. In a number of instances seams have been found to occur over a large territory where mining is now restricted to a few isolated areas. Outcrop maps will be prepared to show the relation of the present mining area to the possible extent of the productive fields.

A systematic study of the fuel values of the various coal has been undertaken. In order that accurate and uniform samples might be obtained, samples that represent the average product of the mine, an assistant of this Department has visited the more important mines of the State and has taken samples from the working face; usually three separate samples were obtained from different portions of each mine. The necessary analytical work was done in the laboratory of the U. S. Geological Survey at Pittsburg, Pa., and later in the laboratory of the Bureau of Mines at the same place. Both the sampling and analyses have been carried out according to methods employed by the Federal Bureaus, assuring uniform results comparable with those of every bituminous coal field which has been sampled and tested by either the United States Geological Survey or Bureau of Mines.

The investigation of the Coal Measures is one of the most important and one of the most extensive researches undertaken by

the Bureau during the past biennial period. The results will bear directly upon an area comprising almost one-half of the entire State. Field work covering the area north of the Missouri river has now been completed, and during the coming season the area to the south will be studied. The results of the work will appear in a report devoted to the economic phases of our coal mining industry. A very brief summary of the work to date is given on page 26.

OIL AND GAS.

During the past few years the Department has received numerous requests for geologic data and maps indicating possible oil and gas fields in Missouri. The major part of the production of these fuels in the mid-Continental fields is obtained from the sandstones of the Coal Measures, where these formations have an arched or dome-like structure, due either to folding or inequalities in original sedimentation. It is near the crest of such folds or domes that the most productive wells are usually brought in.

The structure of the region underlain by the Coal Measures has not heretofore been worked out in detail, although the lower portion of these formations is composed of sandstones and shales having the proper stratigraphic relations for the formation of reservoirs. Because of the direct bearing of the structure on the location of the most favorable territory for drilling, observations on folding have been made in conjunction with the stratigraphic study of the Coal Measures. The final results will be embodied in a report showing the stratigraphy and structure of that portion of the State most favorable for the occurrence of oil and gas. This report will include records showing the formations encountered in deep drilling, which data are extremely valuable to drillers in indicating the character of the strata which are not exposed.

IRON ORES.

With the opening of Iron Mountain in 1844, Missouri became the important iron mining center of the country and for many years held first place as an iron producer. Although the annual output is, at the present time, less than 150,000 tons, the State contains extensive reserves of iron ore in the southeast and central Ozark region.

The ores include specular and red hematites and several types of limonite. They are associated with a majority of the Cambrian and pre-Cambrian formations of the Ozark region and occur under

a variety of geologic conditions, which materially affect, not only the character of the ore but also the methods of mining and the preparation for market.

During the past biennial period a study of these deposits has constituted one of the principal lines of investigation undertaken by this Bureau. The field work has been completed and the report will soon be available for distribution.

Special effort has been made in this work to show the geologic features which have been instrumental in the location of the ore bodies and in affecting the commercial grade of the ores. Through detailed studies of the developed properties, the characteristic occurrence and geologic relationship of each type has been described. By comparison, the observations on the developed properties may be utilized in a study of the undeveloped properties in the State, and through such comparison it is possible for the property owner, mining engineer, or investor to determine the type of ore, and the probable extent and grade of the deposit.

The report includes chapters covering: (1) a history of iron mining in Missouri; (2) the geology and topography of the iron bearing region; (3) types of Missouri iron ores; (4) geology of the brown hematites; (5) geology of the red hematites (sink deposits); (6) geology of the red and specular hematites associated with the granites; (7) detailed descriptions of individual deposits in each county; and (8) observations on commercial conditions.

In addition to a general geologic map showing the location of the various kinds of ores, thirteen county maps have been prepared showing the location of the known deposits in each.

LEAD AND ZINC.

The report on the disseminated lead deposits of St. Francois and Washington counties, which was completed by my predecessor during his administration, was published and became available for distribution during the early part of this biennial period. This report, of which Part I is manuscript and Part II illustrations and maps, discusses in detail the geology and ore deposits of the most important lead mining district of the State. The position of the ore bodies with reference to the various geological formations is given in the case of nearly every important mine in the district and every phase of ore concentration is shown. The dependence of concentration of the ore bodies on zones of faulting and jointing and other geological features is well illustrated. This report which

is the most complete of any yet published by this Bureau covering the lead deposits of the State, has created an active demand for work in the outlying districts of Madison, Franklin and Jefferson counties.

During this biennial period geologic mapping has been carried on intermittently on what is known as the Aurora sheet. This area, which comprises a part of Jasper and Lawrence counties, extends from three miles east of Carthage to the Christian county line and from north of Mt. Vernon to Monett, including the mining camps of Aurora, Sarcoxie, Reeds, Stotts City, and Wentworth. In all it embraces an area of approximately 550 square miles.

At present, mining in these camps is restricted to a comparatively small area, a majority of the intervening territory not having been prospected. The commercial ore bodies of this district have been shown to be closely related to certain geologic features. The present investigation will show these geologic features throughout the unprospected territory and will serve to indicate the most favorable areas for prospecting.

During the past biennial period a complete topographic map of this region has been made in co-operation with the U. S. Geological Survey and the geologic mapping is now more than two-thirds completed.

COUNTY REPORTS.

In addition to the investigations of special economic resources, such as iron ores, building stones, lime, cement, and lead and zinc, the Bureau has in preparation a series of county geological reports. Ultimately each county in the State should be mapped in detail and a report prepared descriptive of its geology and mineral resources. Such reports bring together in a single volume all the facts pertaining to our most important political unit—the county. In pursuance of this plan, the mapping of Jackson and a part of Phelps counties has been started during the past biennial period.

Jackson county—The rapid growth of Kansas City and its suburbs has created a strong demand for structural materials in the form of brick, terra cotta, building stone, lime and cement. Many of the shales, clays and limestones occurring in Jackson county are suitable for use in the manufacture of these materials, and in order that accurate knowledge concerning their distributions and serviceability may be had, a detailed study of the geologic formations underlying this county has been made during the past year.

The geologic mapping indicates accurately the distribution of the clays, shales and limestones. Samples of each have been collected and are now being tested in the laboratory. These tests include complete chemical analyses of the shales, clays and limestones, and burning and shrinkage tests of the shales and clays.

Within the limits of Kansas City, the work is being done on a map having a scale of 200 feet to the inch, the topographic base having been furnished by the Engineering Department of that City. Large scale work of this character is of special value to the Park Commissioners and Engineering Department, as the depths of the various limestones and shales at any point in the City can be computed from the map. The approximate cost of excavations for sewers and other purposes, and preliminary estimates on road building may be computed from this map without sinking test pits or doing extensive field work.

Phelps county—Geologic mapping in Phelps county, including the area embraced by the Rolla quadrangle, the topographic map of which was completed last year, has been started.

The results of geologic work undertaken by the St. Louis and San Francisco Railroad, for the purpose of outlining the most favorable points for drilling a number of deep holes to determine the occurrence of lead or zinc in the lower portion of the Gasconade formation, were given the Department. This work has shown an area of pronounced faulting south of Newburg and drilling is now in progress along this zone.

Using the results of the Railroad Company as a nucleus, mapping has been continued by the Bureau with the view of issuing a bulletin covering the stratigraphy and geologic structure of the Rolla quadrangle. This area is so situated as to be typical of a large part of the central Ozark region. An outline showing the faulted area south of Newburg and a brief descrtiption of the formations occurring in the immediate vicinity is given on page 55.

RECONNAISSANCE WORK.

Scattered throughout the Ozark region, outside of the developed areas, occur numerous prospects of lead, zinc, clay and iron. It has been impossible with the funds heretofore available to undertake detailed studies of these areas and this office has had little information regarding these deposits. During the past field season, Mr. V. H. Hughes has spent considerable time visiting reported prospects throughout the Ozarks in order to determine the more important areas for future work. This reconnaissance work

has shown a number of deposits which warrant more detailed investigation. On page 36 Mr. Hughes has described a number of the localities visited during the season.

CHEMICAL LABORATORY.

As a result of the field work done by the Staff, many samples are collected each year which require chemical analyses in order to determine their commercial value. The Bureau also received hundreds of samples from citizens of the State who desire to know their value. Many of these require careful analyses and the chemist of the Survey has devoted his time partly to analyzing such ores, clays, mineral waters, limestones, tripoli and glass sand. A number of these analyses are given in another part of this report. A greater part of the work, however, is directly connected with the systematic investigations being carried on by the Bureau, and the analyses will be included in the regular reports.

LIBRARY.

Through the medium of exchange with other Geological Surveys and scientific societies, the Bureau has collected a library of several thousand volumes. These volumes are devoted mainly to geology and mining and are of importance for reference in the work of the Department. Approximately 350 volumes have been added during the past two years.

As mentioned in the report of this Bureau to the 45th General Assembly, many of the reports of the scientific societies of American and Europe, as well as the technical journals, often consist of several parts and are received in an unbound condition. In order that these reports may be made of the greatest value, they should be bound and so indexed as to be available for ready reference. This could be done at a cost of approximately $1,000.

MUSEUM.

The Bureau has a geological museum of several thousand specimens consisting of samples of ores, rocks and fossils occurring in various geological formations of this State. These specimens are of great value to one desiring either a knowledge of the grade of ores mined in the State or a knowledge of the general nature and association of the various minerals and rocks. They are of special importance to the members of the Survey Staff as a means of comparison with ores from new or undeveloped localities.

During the past biennial period approximately 400 specimens have been added to the museum, including the most representative collection of Missouri iron ores ever brought together. These specimens include every variety of iron ore known to occur in Missouri and constitute an extremely valuable addition to the museum.

The Director of the Bureau has been placed in charge of the Department of Mining and Forestry at the State Fair and a representative collection of rocks and minerals has been placed on exhibit at Sedalia.

A portable collection of rocks, minerals and clays has been made up and has been exhibited at Springfield, Independence, Moberly, Joplin and St. Louis during the past year. This exhibit includes samples of all ores and stones being mined or quarried in Missouri and has an important educational value.

TOPOGRAPHY.

Topographic mapping during the past biennial period has been carried on in co-operation with the United States Geological Survey, which organization provides not only its trained men, but also pays one-half of the cost of field mapping. The plates from which the maps are printed are engraved at Washington without cost to the State, and electro-types from these plates are furnished to the Bureau without cost.

Under the terms of this agreement, the areas to be mapped are designated by the Board of Managers of this Bureau, while the actual field operations are under the direct supervision of the Director of the U. S. Geological Survey. The scale of work is agreed upon through a conference of representatives of both Departments, and depends upon the economic importance of the area and its surface relief. The mapping during the past biennial period was on a scale of one mile to the inch, with a twenty-foot contour interval.

As there is, at the present time, only a comparatively small portion of the State covered by accurate maps, the Board has placed this work in areas in which there is the most urgent need for geology and topography.

During the past biennial period the Rolla and Aurora sheets, covering an area of approximately 725 square miles, were completed. Field work covering the Green City and Queen City sheets located in Putnam and Schuyler counties is now under way. These sheets comprises an area of 550 square miles and include one of our most important coal mining areas. The Aurora special sheet in-

ɔtts City,

ıvier and
'eas were
ons have
p to date

was 650
i0 square
les. This
econdary
econdary

biennial
sheets.

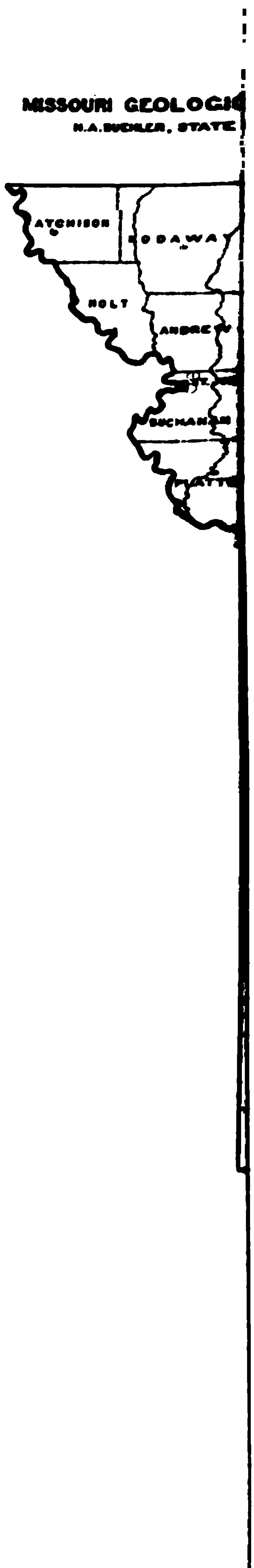
racter is
ortunity
ning the
usually
ıg or de-

ey is to
st from

ject and
letail as
lly, it is
tly hap-
ssary to
to send
t an in-

eveloped
ı which
biennial
that the
au to a

on cov-



ering one of our resources; as for example, lead or zinc, iron, clay, building stone, etc. In answer to such requests our reports are sent, where they will cover the inquiry. Requests are continually received for many of the reports published prior to 1900. These volumes are out of print and can now be obtained only through second-hand book stores.

There is a constantly increasing demand for these publications. The following table indicates the distribution of the reports and maps during the past biennial period:

	No.
Vol. 13	152
Vol. 12	5
Vol. 1	250
Vol. 2	272
Vol. 3	239
Vol. 4	344
Vol. 5	420
Vol. 6	594
Vol. 7	473
Vol. 8	462
Vol. 9	1134
Biennial report (45th)	1200
State Geological Map	900

At the present time the following reports are available for distribution and will be forwarded to any citizen upon receipt of transportation charges:

	Postage.
Preliminary report on Structural and Economic Geology, Vol. XIII, 1900, by John A. Gallaher	25c
Geology of Miller Co., Vol. I, 2nd series, E. R. Buckley, A. F. Smith and S. H. Ball	15c
The Quarrying Industry of Missouri, Vol. II, 2nd series, 1904, by E. R. Buckley and H. A. Buehler	40c
Biennial Report of the State Geologist to the 42nd General Assembly, by E. R. Buckley	10c
The Geology of Moniteau Co., Vol. III, 2nd series, 1905, by F. B. VanHorn	15c
Biennial Report of the State Geologist to the 43rd General Assembly, by E. R. Buckley.	10c
Geology of the Granby Area, Vol. IV, 2nd series, 1906, by E. R. Buckley and H. A. Buehler	20c
Biennial Report of the State Geologist to the 44th General Assembly, by E. R. Buckley.	10c
Public Roads, Vol. V, 2nd series, by E. R. Buckley	15c
Lime and Cement Resources of Missouri, Vol. VI, 2nd series, 1907, by H. A. Buehler	25c
Geology of Morgan Co., Vol. VII, 2nd series, 1908, C. F. Marbut	15c
Geology of Pike Co., Vol. VIII, 2nd series, 1908, by R. R. Rowley	15c
The Geology of the Disseminated Lead Deposits of St. Francois and Washington counties, Vol. IX, 2nd series, 1909, by E. R. Buckley	45c
Geological State Map	10c

CHAPTER II.

FUTURE WORK OF THE BUREAU.

As planned, at present, the geologic work of the Bureau during the coming biennial period will include a continuation of the following partly completed investigations: (1) a study of the coal deposits, (2) the mapping of areas favorable to the occurrence of lead and zinc, (3) a study of the structure of northwest Missouri showing areas most favorable for the prospecting for oil and gas, and (4) county mapping. Although these investigations are among the most urgent, there are others of equal importance that should be given early attention. The publication of data showing the extent of the known deposits of clay, barite, copper, tripoli, cobalt and nickel; the geological formations in which they occur and their location with respect to transportation and markets would not only outline the more favorable localities for prospecting and development, but would greatly assist in eliminating the continual waste of time and money spent in useless research in areas where there is little or no hope of success.

The following brief outline indicates a number of lines of investigation, covering which the survey has no publications available for distribution:

CLAY DEPOSITS.

Missouri is surpassed by few, if any, of the States in the variety and value of her clay deposits, although the extent and importance of the industries based upon their utilization is scantily appreciated by the citizens of the State. In fact, the extent of the undeveloped deposits is hardly comprehended and the possibilities of a more general development of the industries is largely unrecognized.

During 1896 this Department issued a report on the clay deposits, but the demand for this volume was so great that the edition was exhausted before 1900. The constant demand for this report and for information concerning deposits which were not at that time known makes it desirable that a revised edition be published at an early date.

The Coal Measures are composed largely of shales, many of which were not given special attention in the former report. Extensive and valuable deposits of fire clay also occur in the coal mines of the State. The large area over which these shales and fire clays are found as well as their adaptability for use in the manufacture of different clay products makes this an important part of the investigation leading to a revision of that report.

Deposits of kaolin occur not only in Cape Girardeau, Bollinger and adjoining counties but also in the central and southwestern Ozark region. These deposits should be studied in order that suitable methods of treatment may be outlined through which the sand and iron oxide occurring in many of the deposits may be eliminated.

Burning tests, chemical and rational analyses should be made of the clays from all deposits of commercial value. The extent to which there is a demand for this work is indicated by the number of analyses made during the past year in the laboratory of the Survey. A number of the results are given on page 64.

BARITE.

Approximately 50 per cent of the barite mined in the United States comes from Washington county, Missouri. This mineral has, however, rather a wide distribution throughout the south central portion of the State, where it occurs imbedded in the residual surface clays and in veins which frequently extend to considerable depth. It is usually associated with galena and is found chiefly in the geological formations of the Cambrian.

Barite is utilized extensively in the manufacture of white paints and in a number of other industries.

A report should be prepared showing the distribution, geologic association and commercial possibilities of this mineral, which is so little known outside of the immediate districts in which it is mined.

COBALT AND NICKEL.

During the past few years Missouri has been the chief producer, in the United States, of the semi-rare metals, cobalt and nickel; an extensive deposit of these ores having been developed near Fredericktown in Madison county. Similar deposits also occur on the Mine Lamotte tract but they have never been mined for these metals, which have only been recovered in small amounts as a by-product in the smelting of the lead ore with which they are associated.

In geologic position, the ore is apparently closely related to the granites and porphyries of the district, being found in the Bonneterre limestone and Lamotte sandstone near their contact with the igneous rocks. Geological conditions similar to those near Fredericktown occur over a large area in Madison county. Accurate geologic mapping would indicate the areas in which such contacts occur, and would serve as a most valuable guide to future development work.

SAND AND GRAVEL.

The St. Peters sandstone furnishes the pure white sand used in the manufacture of plate glass at the large factories located at Valley Park and Crystal City. This formation outcrops over a rather irregular area extending through several counties in the eastern portion of the State. It has been mapped in Franklin and Jefferson counties from Labadie on the Missouri river to Crystal City on the Mississippi river. This work should be extended to the south through Ste. Genevieve, Perry, and Cape Girardeau, and north through St. Charles, Warren and Montgomery counties, in which areas this formation is known to occur. In addition to a study of the glass sands, the deposits of building sand and gravel should be investigated. The output from these deposits has a value of about $1,000,000 annually.

TRIPOLI.

Extensive deposits of tripoli occur throughout the western portion of Newton county, Seneca being one of the most important centers of production in the United States. This material, which is a partially decomposed flint, is used extensively in the manufacture of filters and polishing powder.

Deposits having a similar chemical composition, which are locally known as "silica" occur in Ste. Genevieve, Perry and other counties of southeastern and central Missouri. The accurate locations of such deposits of tripoli would materially assist in their future development.

COPPER.

Ores of copper have been found throughout the Ozark region and have been mined and smelted intermittently near Sullivan, Eminence, Ste. Genevieve, and Fredericktown. They are frequently encountered with the iron ores of the central Ozark region

where with depth this ore appears to be quite persistent. Copper is also found to some extent in the disseminated lead district but no special endeavor is made to separate it.

These ores occur under different geological conditions and are associated with several geological formations. They have never been studied in detail by the State Survey, although a complete report would serve to indicate the various modes of occurrence and the possible future of the industry.

MINERAL PAINTS.

Ocherous iron ores, ground limestone, lead and zinc ores, ferruginous clays, and barite are all used in this State in the manufacture of mineral paints, the total output being valued at more than $1,500,000 annually.

The chemical and physical characteristics requisite for each of these raw materials, their distribution and occurrence, the processes necessary in the preparation for market, and the demand for and uses of each of these pigments should be included in the text of a report covering these industries.

DEEP DRILLING.

In conjunction with the work on oil and gas and the investigation covering mineral waters, the Department should devote more attention to obtaining accurate records of deep well drilling. These records not only serve to show the nature of the geological formations penetrated, but provide a fund of information relative to the underground waters of the State; a factor of the greatest importance to every city and village. This information is now obtained only through correspondence. One assistant should be employed to visit each well being drilled and arrange to obtain cuttings, and samples of water, from which a complete record may be compiled.

COUNTY REPORTS.

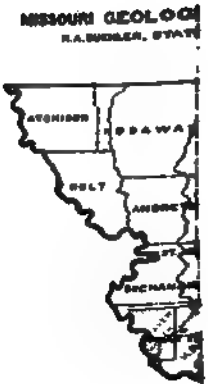
As shown on the accompanying map, there are 53 counties of which there has been no detailed or reconnaissance reports published. At the present time, detailed reports covering Miller, Morgan, Moniteau, Pike and parts of Washington, St. Francois and Newton counties are available for distribution. Similar reports covering Greene, Lincoln, and parts of Henry, Lafayette, Ray, Randolph, Chariton, and Macon counties have been published but are now out of print. The reports covering the remaining counties


ATCHISON
HOLT

al forma-
the Geo-
ent detail

county in
fact that
ering, not
and value
other ma-

k in Jack-
nd Phelps
arts of the



for by en-
ordinary
ords which
field. As
a matter
e maps is

co-opera-
piled from
surveyed,
. The im-
touch al-
by far the
ents each)

State cov-
tter were
show the
maps are

ogical Sur-
t one-third
reparation
he Federal
penses and

consist mainly of very brief descriptions of the geological formations and are the result of reconnaissance work done by the Geological Survey at an early date. They are not in sufficient detail to be of great economic value.

A detailed geological report should be made of every county in the State. The value of such areal reports lies in the fact that they assemble in one volume all the available data covering, not only, the geology and surface features but the occurrence and value of the deposits of ores, clay, stone, mineral waters, and other materials of economic value.

The Department has recently completed the field work in Jackson county and is mapping areas in Lawrence, Jasper and Phelps counties. Similar work should be undertaken in other parts of the State as rapidly as the appropriation will permit.

TOPOGRAPHY.

Accurate topographic maps are continually sought for by engineers, land owners, educators, and investors. The ordinary county or State map is usually compiled from office records which frequently do not correspond to actual locations in the field. As the State becomes more thickly settled and land lines are a matter of ever increasing importance, the demand for accurate maps is greatly increased.

The topographic maps made by this Department in co-operation with the United States Geological Survey are compiled from actual field surveys. Each forty acre tract is accurately surveyed, giving every cultural and natural feature of prominence. The importance of such maps cannot be over-estimated. They touch almost every phase of public and private interest, and are by far the most accurate maps published. The low price (five cents each) makes them available to every citizen.

The map opposite indicates the area of the State covered by detailed and reconnaissance maps. The latter were made some twenty years ago and are only intended to show the more prominent features of the country. The detailed maps are made with much greater accuracy.

Through co-operation with the United States Geological Survey the cost to the State of preparing these maps is about one-third of what it would be, were the State to undertake their preparation independently. Under the terms of this agreement, the Federal Government not only pays one-half of the actual field expenses and

one-half the cost of drafting, but also undertakes the engraving and printing without cost to the State.

While a number of States have made complete topographic maps covering their entire area and others have such surveys nearing completion, Missouri only began this work on a comparatively small scale four years ago. The importance of our water resources, mining interests, drainage projects, forestry problems, soil surveys, and other natural resources has created a strong demand for these maps and additional areas should be mapped as soon as possible. It is planned to extend this work near our important mining and commercial centers as rapidly as funds will permit.

APPROPRIATION NECESSARY.

On the foregoing pages a few of the important problems awaiting the attention of the Bureau are indicated. These problems do not include mention of the educational work of the Department, the preparation of mineral collections for High Schools and Colleges, the gathering of mineral statistics, nor the preparation of general reports covering the detailed study of many of our geological formations, which studies are very necessary in order to obtain the proper facts upon which to base deductions. Each of these subjects should be given more attention.

It is evident that with the appropriation heretofore available the majority of these problems can be given only passing consideration for many years to come. The rapidity with which complete results may be obtained will depend entirely, upon the appropriations granted the Department. The results should be made available to each industry as soon as possible.

The service which the Bureau has already rendered the State in the rational development of our mineral industries cannot be estimated. That its reports are of material assistance is indicated by the continual demand for each of the volumes published. That the advice of the Bureau is valued is indicated by the almost daily requests for every kind of information.

As shown by statistics covering the output of our mineral resources, the total production of our mines, quarries and clay plants has increased from a value of $13,000,000 in 1898 to approximately $45,000,000 in 1908. This increase during the past decade has greatly increased the demands upon the Bureau, which is at present operating on almost the same appropriation received ten years

ago. During this time every mining, clay working and quarrying territory in the State has been greatly expanded.

In order that we may not only keep in touch with this development, but may precede it by pointing out those geologic features of especial importance in prospecting, the Department must materially enlarge its activities. It must place more assistants in the field if it is to be of the greatest help to the mining industries of the State.

We, therefore, earnestly recommend that the following appropriation be made for the work of this Department during the next biennial period:

Support	$40,000.00
Publications	5,000.00
Topography	20,000.00
Total	$65,000.00

THE PRINCIPAL COAL FIELDS OF NORTHERN MISSOURI.

BY HENRY HINDS.

Recognizing the importance to the country at large, as well as to the citizens of the State, of the coal deposits of Missouri, the Missouri Bureau of Geology and Mines, early in 1910, entered into negotiations with the U. S. Geological Survey at Washington for co-operation in making a systematic study of the coal fields of Missouri. It was arranged that the expense of this undertaking should be shared equally by the two organizations and the author was detailed by the Federal Survey to take charge of the field work, with F. C. Greene of the State Survey as assistant. Under an arrangement previously made between the State Geologist and the Technologic Branch of the U. S. Geological Survey, coal samples had been collected from the principal coal mining centers of the State and the chemical analyses and thermal determinations made of these samples are to be incorporated in the final report on the coal deposits.

During the field season of 1910, work was carried on in northwestern Missouri by F. C. Greene and in north-central, central and west-central Missouri by the Author. Mr. Greene's investigations were confined chiefly to that part of the State that contains rocks of the upper Pennsylvanian age. The writer visited the remainder of the potentially productive coal territory of northern Missouri, consisting of all or in part of the following counties: Harrison, Mercer, Putman, Schuyler, Scotland, Clark, Grundy, Sullivan, Adair, Lewis, Livingston, Linn, Macon, Shelby, Clay, Ray, Carroll, Chariton, Randolph, Monroe, Ralls, Lafayette, Saline, Howard, Boone, Audrain, Callaway, and Montgomery. Geological features were noted, available drill records obtained, and all active coal mines entered and examined. Efforts were made to determine the area underlain by each coal bed, the conditions affecting its commercial adaptability, and its geological relationships. The present article is merely a brief and incomplete abstract of the facts ascertained, full details being reserved for the final report that will be issued when the entire coal area of the State has been examined.

All coal found in northern Missouri forms part of the Pennsylvanian series of the Carboniferous system and this series embraces the youngest indurated rocks of the State. The Pennsyl-

vanian is classified on lithologic and economic grounds as consisting of an upper group called the Missouri and a lower group known as the Des Moines. The Missouri group is distinguished by an abundance of limestone and contains little coal of importance. The Des Moines group is now usually regarded by Missouri geologists as consisting of three divisions; viz, the Pleasanton shale above, the Henrietta limestone and shale next below, and the Cherokee shale at the base. The Pleasanton contains very little coal and, in northern Missouri, is a succession of sandstones and shales ranging in thickness from 100 to 150 feet. The Henrietta, which is from 50 to 90 feet thick, is rendered more or less distinct from the Pleasanton and Cherokee by the greater amount of limestone it contains. The Henrietta bears important, though thin, beds of coal, and these are extensively mined in Lafayette, Ray, Putnam, and other counties. Henrietta coals excel for domestic purposes and are comparatively free from iron pyrites, though always showing white scales of gypsum and calcite along the joint planes. They are all overlain by black fissile shale, known to miners as "slate," and this in turn by limestone caprocks. The roof of the coal is invariably strong and often ideally adaptable to the long-wall system of mining. Henrietta strata show marked persistency over wide areas. The Cherokee consists chiefly of shale, sandstone and clay, with a very little limestone and some important coal beds. The upper portion of this formation contains most of the coal now mined and the strata that are persistent in lateral extent; the lower portion contains basin deposits of considerable irregularity of thickness and lithological characters. Cherokee coal beds are best adapted to steaming purposes, are of all thicknesses up to six feet, and commonly have shale roofs of doubtful stability. The Cherokee lies unconformably upon the irregular upper surface of the Mississippian limestones and its thickness is variable.

The coal fields of chief commercial importance in northern Missouri are: Bevier, Lexington, Novinger, Mendota, Marceline, Vandalia, and Cainesville.

THE BEVIER FIELD.

This field is one of the most important in Missouri, containing as it does the Bevier coal, a bed of wide areal extent and fair thickness. In a broad sense, the workable portion of this bed is bounded on the east by the Wabash railroad from Macon City through Moberly and Centralia to Columbia, on the north by the Hannibal &

St. Joseph division of the Burlington system, on the west by the Middle Fork of the Chariton river, and on the south by an irregular line passing through Salisbury, Yates, Russel, Harrisburg and Columbia. An important tongue of the Bevier coal projects beyond Middle Fork into the northeastern corner of Chariton county, but is mined only at one place; viz, Fish Trap Ferry on the Chariton river. It is very probable that future prospecting will reveal workable outliers of the Bevier bed north and east of the boundaries named above. By no means all of the land within this territory is underlain by the Bevier bed; the coal has been cut out in the valleys of the main streams by pre-glacial drainage channels at numerous points, and by a channel of Pennsylvanian age in central Randolph county. These points will be brought out much more fully in the final report by means of maps and descriptive text.

The northern portion of this field, the Ardmore District in Macon county, is the most important, both because a greater quantity of coal is mined there than in any other single district in the State and because the coal is slightly thicker than farther south. The average thickness of the bed is 4 1-2 feet, though it is in places one or two feet above or below this average. A clay band averaging two inches in thickness splits the coal about one foot from its base. Locally this band becomes hard and arenaceous and thickens so as to become somewhat troublesome. At Lingo, where a detached area of the Bevier bed was formerly mined, this thickening of the clay band was especially notable. The roof of the Bevier bed in the Ardmore district is a sandy shale or a sandstone, changing abruptly from one to the other. The sandstone makes a firm roof, but has a tendency to cut down into the coal so as to make the thickness of the latter variable. The shale roof is of fair stability when proper precautions are taken.

One other bed, the Macon City coal, is of present economic importance on the eastern border of the Ardmore district. It lies from twelve to thirty feet above the Bevier and is about two feet thick. It is mined in and near Macon City, where it is of excellent quality and possesses a very strong roof. Other coal beds known to occur in this district will be described in the final report.

The Huntsville District of the Bevier field occupies the northwestern quarter of Randolph county west and north of the Wabash railroad, and the adjoining edge of Chariton county as far west as Salisbury. The coal of the Bevier bed is slightly thinner here than in the Ardmore district, averaging three and one-half to four feet, but is otherwise similar. Mining centers are Huntsville and Kim-

berly. Mining at Salisbury has not proved very profitable because of the thickening of the clay parting in the Bevier bed at that point. The Macon City coal is not mined within the limits of this district, though local trade is supplied from the same or a very similar bed at points near the M. K. & T. railroad between Moberly and Paris.

The Higbee District of the Bevier field lies in the south-central portion of Randolph county, west of the Wabash railroad, and the northeastern corner of Howard county. It is separated from the Huntsville district by a channel of late Pennsylvanian age in which the coal is replaced by sandstone and shale. The Bevier bed has been opened by shipping mines at and near Higbee, Yates, Elliott, Renick and Russel, and averages three and one-half feet in thickness with the usual thin clay band in its lower half. The roof is not quite so strong as in the northern districts, being an argillaceous shale that requires careful attention. The Macon City coal is mined at Renick, where it is eighteen inches thick and has an excellent roof of firm black shale overlain by a limestone cap-rock.

The Columbia District of the Bevier field is the continuation to the southeast of the Higbee district. The Bevier coal, averaging three to three and one-half feet in thickness, underlies the divides in the northwestern quarter of Boone county. Mining for local trade is prosecuted near Harrisburg, Rucker, and other points, and in a slightly more extensive manner near Columbia. Mining conditions are much the same as in the Higbee district, yet the Boone county area has not received the attention it merits. Improvement in railway facilities may mean more extensive mining of the coal. Another coal, about two feet thick and forty feet higher than the Bevier, underlies the higher lands of the district, while an eighteen-inch bed lies, at least locally, a short distance below the Bevier coal.

THE LEXINGTON FIELD.

The Lexington coal field equals the Bevier field in present importance, in spite of the fact that its only coal bed averages little more than twenty inches in thickness. This coal, the Lexington bed, is of excellent quality, as will be shown when analyses are published, can be mined very economically, and is located near large centers of fuel consumption. The roof of the coal is a strong limestone, in many localities separated from the coal by a thin stratum of black fissile shale ("slate") that can be conveniently taken down to make the requisite height along the face and used to build gob walls.

The Richmond District includes that portion of the Lexington field lying north of the Missouri river bottoms; viz, all of Ray county, except perhaps the northeastern corner, and at least the southeastern quarter of Clay county. The status of the Lexington coal bed in the remainder of Clay county and in Caldwell county will be discussed at a future date. In the greater part of the district the coal lies in two benches with limestone resting on the coal, thus:

	Ft.	In.
Limestone	5	..
Coal, pyritiferous (top coal)	0	5
Clay	0	2
Coal, clean (bottom coal)	1	7

This type of bed is found at and near Richmond, Vibbard, and Knoxville. In places, notably between Swanwick and Richmond and near Lakeview, the top bench is irregular or lacking and more rarely the upper portion of the bottom bench is absent. When traced from Richmond to Camden the top coal gradually disappears, its place being taken by black shale. At Camden, Fleming, Orrick, and Missouri City, the following is the average section:

	Ft.	In.
Limestone	7	..
Shale, black ("slate")	0	10
Coal	1	9

There is a vast amount of coal in the Richmond district still untouched.

The Higginsville District of the Lexington field includes all of Lafayette county except the eastern edge and the southeastern corner, where the country is topographically too low to contain the Lexington coal bed. In this southeastern corner, however, there is a lower coal called the Mulky bed, much like the Lexington bed in thickness and character; while at Waverly, in the northeast corner of the county, is a large basin of still lower coal that is four feet thick and has a roof of thick shale. The Lexington bed of the Higginsville district was cut out and replaced by sandstone and shale in an ancient channel several miles broad that lies between Lexington and Dover and extends thence southward to beyond Higginsville; and it has been removed more recently from the valleys of the major creeks. East of Lexington the coal is the same as at Richmond, being in two benches. At Dover the coal is as at Lakeview, in two benches but subject to rather abrupt and irregular thinnings. South and west of Lexing-

ton, where the most extensive mining is conducted, the coal bed is the same as at Camden, though the black shale between the coal and the limestone is a few inches thicker. West and south from Wellington and south from Lexington the thickness of coal decreases gradually, so that at Napoleon it is only seventeen inches and at Mayview only sixteen inches. Northwest and southwest of Odessa there is only from ten to sixteen inches of coal. Near Higginsville the coal is of the Camden type, but is only from fourteen to eighteen inches in thickness. The excellence of mining conditions, however, the superior quality of the coal, and the advantageous location of the town as regards shipping facilities have caused extensive mining to be prosecuted near it. Near Corder the thickness of the coal averages twenty-one inches, though somewhat decreased locally by "horsebacks." North and south of Corder there is a considerable area of coal land practically untouched.

THE NOVINGER FIELD.

The Novinger field is the third in importance in northern Missouri in point of present production. As now known, it embraces the northwestern quarter of Adair county, reaching its fullest development in the neighborhood of the Iowa & St. Louis railway between Youngstown and Connellsville, where the coal worked is reached by slopes and shafts. It is probable that future prospecting will reveal lucrative basins of coal between the Novinger and Bevier fields. The average section of the bed mined at Novinger and Connellsville is:

	Ft.	In.
Shale	..	..
Coal	2	2
Clay	..	0.½
Coal	..	4
Clay	..	1
Coal	1	..
Total coal	3 ½ ft.	

This coal is excellent for steaming purposes, is very hard, and somewhat dirty at top and bottom. The shale roof requires rather careful attention. The long-wall method of mining is being introduced as an experiment: its success would mean that a great impetus would be given to mining in this and similar fields. East of Novinger, near Kirksville, the shale over the coal is replaced by a sandstone that has a very uneven under-surface, cutting down badly into the coal in rolls. Under Kirksville itself, the Novinger bed is so thin as to be unworkable. West of Novinger, at Danforth, a trou-

blesome "bench rock" splits the coal and thickens towards the west. At Stahl the Novinger bed is thirty inches thick, and a short distance west, at Dewey, it is still thinner. No systematic prospecting has been done between Dewey and Milan, the next point west at which coal is known to occur.

A coal bed that is from twenty-four to thirty inches thick lies about fifty-five feet below the Novinger bed, but no coal has yet been taken from it. The bed now mined at Stahl lies about ninety feet above the Novinger coal and will be mentioned under the next heading.

THE MENDOTA FIELD.

The Mendota field includes practically all of Putnam county, the northwestern corners of Schuyler and Adair counties, and the northeastern quarter of Sullivan county. There is a vast area of undeveloped coal land in this field, the value of which is scarcely realized. The coal present constitutes the southern extension of the bed termed the Mystic coal in reports of the Iowa Geological Survey, a bed that produces near Mystic, Centerville, Cincinnati and Seymour nearly one-fifth of Iowa's large coal output. In Missouri this bed is easily reached by drifts in the valleys of Blackbird, Shoal and Shuteye creeks, the lower part of Spring creek, and the Chariton river near the Iowa-Missouri line. Numerous small country mines are found in all these localities, but shipping mines are developed only near Mendota, Unionville, Stahl, and Coal City. The following average sections show the thickness of the coal and the nature of the overlying strata in the different districts:

AT MENDOTA AND UNIONVILLE.

	Ft.	In.
Limestone ("cap-rock")	1	6
Shale, drab ("clod")	..	7
Shale, black ("slate")	1	3
Coal	1	7
Clay parting ("mud-band")	..	2
Coal	..	11
Clay parting	..	1
Coal ("Dutchman")	..	1
Total coal	2 ft., 7 in	

AT STAHL.

	Ft.	In
Limestone ("cap-rock")	2	..
Shale, drab (clod")	1	..
Shale, black ("slate")	1	..
Coal	2	..
Clay ("mud-band")	..	2
Coal	..	10
Clay	..	0.½
Coal ("Dutchman")	..	1
Total coal	2 ft., 11 in.	

AT COAL CITY.

	Ft	In
Limestone ("cap-rock")	1	6
Shale, soft ("clod")	..	10
Shale, black ("slate")	1	..
Coal	1	8
Clay ("mud-band")	..	2
Coal	1	1
Clay	..	1
Coal ("Dutchman")	..	3
Total coal	3 ft.	

The coal is excellent for domestic purposes, being rather free from iron pyrites and coming from the mines with a very small percentage of slack and small coal. It is probable that workable basins in lower coal horizons also exist in this field in addition to those of the Novinger bed that are known to underlie the Mendota coal near Stahl. Details will be discussed in the final report.

THE MARCELINE FIELD.

The Marceline field occupies the southeastern portion of Linn county and the adjoining northern edge of Chariton county. Coal is mined rather extensively at Marceline and for local needs at Bucklin, Brookfield, and Rothville. At least three beds of coal are known to underlie this field, only one of which, the lowest and thickest, is utilized to any great extent, though one of the higher thin beds is mined a little near Rothville and Brookfield. A fourth bed, said to be thirty-two inches thick, is reported to lie about seventy feet below the lowest coal now worked. The bed worked is reached at Bucklin by a shaft 228 feet deep and at Marceline by three shafts respectively, 130, 190, and 212 feet deep. It is slightly irregular in thickness, being affected by "rolls" in the roof and the floor, and averages about twenty-nine inches of coal. It is rather dirty at Marceline and careful cleaning is rendered necessary by the presence of considerable iron pyrites ("sulphur"). The roof is a shale of fair strength. The field is commercially important because it is the only producer of coal along the line of the Atchison, Topeka & Santa Fe railway between Carrollton and Clark county.

VANDALIA FIELD.

The Vandalia field is perhaps better known for its fire clays than for its mineral fuel, yet there is immediately above these

clays a coal bed that is mined in rather a small way at and near Perry, Vandalia, Farber, Laddonia, Martinsburg, and Wellsville. This bed underlies the southwest corner of Ralls county, the extreme southeast corner of Monroe, the vicinity of Wellsville in Montgomery, and all of Audrain county east of a line drawn up the South Fork of Salt river to Mexico and thence southeasterly. Although several beds are known in this area, only one, known as the Vandalia bed, is considered workable. The Vandalia bed is of good quality locally, but contains numerous patches of poor coal where "slips" and "clay seams" are numerous. The roof over the bed is a hard, blue-back shale ("slate") that is lithified in places and bears ovoid concretionary boulders of impure limestone. The average measurement of the coal near Perry, where it is reached by drifts and shallow shafts is:

	In.
Coal	20
Clay	0.½
Coal	5

In the remainder of the Vandalia field, where the coal is reached by shafts, the deepest of which is 110 feet, the bed worked averages:

	In.
Coal	20
Pyrite	0.¼
Coal	10

The product of this field is consumed largely within its own borders.

THE CAINESVILLE FIELD.

Recent discoveries at Cainesville, in Harrison county, have resulted in the sinking of a deep coal shaft by a strongly capitalized company and a large output may be expected in the near future. The bed that it is planned to work lies nearly 500 feet beneath the surface and is said to be four and one-half feet in thickness. Other somewhat thinner coal beds are also known to be present. This field will be visited in 1911 and described in detail. Drilling at neighboring points in Missouri and Iowa seems to indicate that the prospect of finding basins of valuable coal at considerable depth in this region is decidedly bright. It should be remembered, however, that these deep coal beds are well down in the Cherokee shales and are more likely to be in series of large basins lying at definite horizons than to be blanket beds extend-

ing uninterruptedly over a great expanse of territory. In other words, mining conditions are more apt to be like those encountered in Iowa, in Monroe, Polk, Mahaska and other counties than to be those of the Bevier and Lexington fields in Missouri.

OTHER COAL FIELDS.

Coal is known to be present in beds of moderate thickness at many localities in northern Missouri not already mentioned. Space does not permit of describing them in this brief abstract. The most important of these localities are Milan, Trenton, Melbourne and Fulton. Coal is also found in eastern Clark county and near Chillicothe, Sumner, Carrollton, Keytesville, Blackburn, Slater, Fayette and numerous other points, all of which will be described in the final report. In brief, it may be said that northern Missouri contains immense reserves of coal in beds of fourteen inches to six feet in thickness that are easily accessible. When compared with the amount left undisturbed, the amount of coal already taken out is almost infinitesimal; only near Lexington and Bevier has the depletion of easily available coal lands begun to make itself a problem. As will be more generally recognized in the future, nature has been generous with Missouri in storing great coal reserves, with all that means for commerce and manufacturing, within her borders.

RECONNAISSANCE WORK.

BY V. H. HUGHES.

During the past field season reconnaissance work was undertaken throughout the southern portion of the State in order that the Bureau might have information regarding prospects and mines located in those districts in which detailed geological work has not been done.

The following pages are devoted to a brief description of the more important areas visited and include a number of geologic features which, because of their bearing on the possible development of important mining areas, deserve future detailed work.

Among these, the fractured zone in Taney county, which was mapped for a distance of seventeen miles, shows an area in which lead and zinc ores have been found, but which has not been prospected sufficiently to determine its true value. The region of pronounced folding and faulting found in Crawford county, within which the Davis shale and possibly the top of the Bonne Terre dolomite is exposed, shows an area thought to be favorable for the occurrence of disseminated lead ore. This exposure of the Davis shale is approximately 30 miles west of the exposures in Washington county.

The examination of the known carbonate of zinc deposits occurring in those counties bordering the central portion of the Arkansas State-line indicates that the same geologic conditions exist over an extensive area and that systematic prospecting would develop additional commercial ore bodies.

DALLAS COUNTY.

This county is underlain chiefly by formations of the Cambrian series, which, due to the rough topography, are well exposed over a large part of the area. Those formations noted during this work belong to the Gasconade and Roubidoux, with an occasional outlier of Burlington limestone belonging to the Mississippian.

GASCONADE FORMATION.

This formation is composed of massive beds of cherty and non-cherty dolomite, which varies from a medium to a coarse grained, crystalline texture and usually has a whitish to grayish

blue color on a fresh fracture, while the weathered surface is a dark gray. The chert occurs as heavy beds and as nodules scattered throughout the formation. It is usually white or blue-white in color, although in several instances blue-black chert was observed. Southwest of the village of Wall Street massive beds of oolitic chert were observed near the top of the formation.

At Tunas in the north part of the county, a few beds of sandstone are exposed in the low bluffs occurring along Little Niangua river. These beds occur low down in the Gasconade and probably belong to the Gunter sandstone at the base of the formation. This is the lowest exposure, geologically, observed in the county.

ROUBIDOUX FORMATION.

The Roubidoux formation as recognized in the Ozark region consists of two dolomite and two sandstone members which aggregate 100 feet in thickness. Of these, the upper sandstone member is easily recognized in Dallas county. It underlies the high upland area and attains a thickness of 30 feet. On the undulating table land areas exposures of sandstone are of frequent occurrence along the smaller streams. This is especially true of the prairie area extending westward from Buffalo. In Sec. 34, T. 35, R. 20, where this sandstone has a thickness of 25 feet, it is fine grained, but so loosely cemented that a fresh fragment from the interior of the bed may be reduced to individual sand grains by crushing between the hands. It is white in color and apparently would make a good glass-sand. A pinnacle, known locally as "Lone Rock," situated on a high ridge one-half mile east of Tilden is an erosion outlier of this bed.

BURLINGTON FORMATION.

One or two outliers of the Burlington limestone occur in the western edge of the county. The limestone is blue-gray in color, coarsely crystalline in texture and contains some nodular chert. Residual chert from the Burlington formation is found in many parts of the county, but with the exception of comparatively small outliers the formation has been entirely eroded from this region.

MINING DEVELOPMENTS.

With two probable exceptions, all of the prospects visited in the county are located in the Gasconade formation. Much of the

"float" lead found in various localities throughout the county is undoubtedly residual from that formation.

The following prospects and mines have been worked within the past few years, but none of them are producing at the present time.

James Evans Prospect—This prospect is located in the N. E. ¼ N. E. ¼ Sec. 34, T. 35, R. 20. The forty is traversed from north to south by a small stream, along the east bank of which several shallow shafts have been sunk through residual clay and chert fragments to the solid rock. Large corroded crystals of galena were imbedded in this residual material.

Several thin seams of galena have been found filling joints in the solid dolomite exposed in the stream bed immediately below the workings. A section of the rocks in the immediate vicinity of the shafts shows in descending series:

4 ft. fine grained sandstone.
5 ft. fine, crystalline, cherty dolomite.
4 ft. fine grained dolomite.
4 ft. heavy bedded crystalline dolomite containing small lenses of decomposed chert.

These beds probably belong to the Roubidoux formation.

Henry Booth Shaft—This prospect is located on the south bank of a small branch in the N. W. ¼ S. W. ¼ Sec. 1, T. 35, R. 20. The shaft is 40 feet in depth, the upper 10 feet of which is entirely in residual clay and chert fragments carrying a considerable quantity of galena. The remaining 30 feet of the shaft was driven through solid dolomite, the upper 10 feet of which shows the effect of extensive leaching. The cavities resulting from this leaching process have been partially filled with calcite, together with small amounts of lead, zinc and iron sulphides. These beds do not apparently contain sufficient lead and zinc to warrant exploitation. The lower 20 feet encountered thinly bedded, finely crystalline dolomite which does not show solution effects. In this portion of the shaft the mineral is reported to have occurred filling occasional joint planes in the rock.

Considerable "float" lead has been found on the surface in the immediate vicinity of this shaft.

SMITH MINES.

These diggings, which consist of five shafts or test pits, are located in Sec. 35, T. 36 N., R. 20 W. The property has been abandoned for a number of years and the openings are now filled with detrital material. From the information obtained, three of

these shafts, the deepest of which was 100 feet, were sunk on an irregular opening, or solution fissure. This fissure has a general northeast-southwest strike and a maximum width of three feet. It was filled with residual, cherty clay carrying a considerable quantity of galena. Senator Henry Booth reports that 100,000 pounds of this ore were mined from these openings. Two shallow shafts or pits, which were sunk on either side of the fissure, encountered bedded rock at a depth of 14 feet. Some float galena was found in the residual clay overlying the solid rock.

SHAFT AT TUNAS.

This shaft, which has a depth of 85 feet, is located on the east bank of Tunas Fork near the west edge of town. It was sunk on a solution "fissure" or opening which has a general northeast-southwest strike and which varies from six to eighteen inches in width. This opening was filled with a very loosely cemented breccia consisting of finely broken chert, dolomite and sand. Throughout the depth of the shaft the breccia carried ores of both lead and zinc. The shaft was abandoned because of the inability of the operators to successfully cope with the water, which increased with depth.

Along Tunas Fork immediately west and north of the above shaft, bedded dolomite and sandstone form a low bluff line along the west side of the stream. These beds belong to the lower portion of the Gasconade formation and may include the Gunter sandstone horizon.

HILDEBRAND DIGGINGS.

These diggings are located 1-4 mile north of Tunas on the west bank of Tunas Fork. Here, the ground over an area 100 feet square has been thoroughly exploited by means of several shafts, the deepest of which was sunk to a depth of 100 feet.

Mining was restricted to a "pot hole" or "chimney" occurring in the lower Gasconade dolomite. This "chimney" was filled with residual clay and chert fragments carrying a considerable quantity of massive galena, one boulder of which is reported to have weighed 1,200 pounds. Several tons of this mineral were produced from these diggings. The area has been abandoned for several years.

HATFIELD DIGGINGS.

The Hatfield diggings are located along the base of a bluff on the south side of a small stream one mile north of Tunas. Three

shafts were opened at this place, the deepest of which was sunk a distance of 40 feet. This shaft followed a solution fissure varying from six to eighteen inches in width. The opening has a general north-south strike.

Similar conditions prevail here as at the Tunas shaft. Near the surface the material filling the crevice consisted of clay and chert fragments, while in the lower extremities of the shaft a breccia similar to that found in the Tunas shaft was encountered. The wall rock on either side consists of finely crystalline dolomite.

Pockets of galena occur scattered throughout the breccia, but no ores of zinc were found.

Small amounts of float lead have been picked up in the bed of the adjoining stream, and in the fields surrounding the shaft.

These shafts were sunk at the same horizon in the Gasconade formation as the one at Tunas. No work has been done here for several years.

RAMBO DIGGINGS.

This property, from which a large quantity of lead ore has been mined in the past, has been the most important producer in Dallas county. It is situated on the northern edge of a table-land area southwest of the village of Lead Mine. Mining has been confined to a large "chimney" which was discovered through the occurrence of a small amount of float galena, and not through any original surface features which might indicate such conditions.

The pit from which the ore was mined is roughly elliptical in shape, having a maximum diameter of 200 and a minimum diameter of 150 feet. The pit, which is now partially filled with detritus, is about 70 feet deep, although originally it was worked to a depth of 85 feet. From the bottom of the pit to within 12 feet of the top, massive beds of dolomite form a precipitous wall around nearly the entire circumference of the excavation. Originally, the faces of the dolomite wall were very irregular, the jutting ledges having been removed to facilitate mining operations. The dolomite is overlain with 12 feet of residual clay and chert. The pit was originally filled with similar cherty clay, in which was imbedded small and large masses of galena, which was easily cleaned by washing.

During the last few years that the mine was worked a cable tram and bucket system was used in hoisting the ore. When mining ceased at the 85-foot level, clay and fragments of chert composed the floor of the pit and it is quite probable that operations

could be carried to a considerable depth before encountering solid rock.

SIEGEL MINES.

This property is located near the north line of Sec. 35, T. 35 N., R. 19 W. Two shafts have been sunk, one to a depth of 185 feet, the other to a depth of 40 feet. Both shafts have been sunk on a solution crevice which varies from six to twelve inches in width, and has a general northeast-southwest strike. The crevice was filled with a dolomite breccia, carrying calcite and varying amounts of zinc sulphide. In places this breccia occurred firmly cemented, while at other points it was quite friable, consisting of small fragments of chert and sand-like crystals of dolomite which had their origin in the leaching of the side walls.

No galena was encountered in either shaft.

Throughout this and adjoining counties similar diggings indicate that a large part of the lead and zinc ores has been found in the residual clays, and in what are locally called "fissures," "chimneys," and "pot holes." The latter openings are the result of the solution of the limestone and frequently contain considerable mineral. Wherever the Gasconade limestone has been subject to such weathering processes, there is a possibility of the occurrence of similar dposits.

DOUGLAS COUNTY.

SHAFT NEAR GRANADA.

In a small valley one-half mile north of Granada a shaft has been sunk to a depth of 60 feet, at which level a considerable amount of drifting was done. The shaft and workings were driven through heavy bedded, crystalline dolomite of the Jefferson City formation. Near the surface the beds are dense, finely crystalline and contain considerable chert in the form of nodules and lenticular masses. At the bottom of the shaft and throughout the drifts the dolomite shows extensive leaching, which has resulted in the formation of numerous cavities. The cavities are partially filled with calcite, galena, jack and occasional small crystals of tetrahedrite (copper-iron sulphide). The property is not being worked at the present time.

MONAHAN DIGGINS.

This property, located about one mile northeast of Ava, has been prospected by means of several pits and open cuts in the sur-

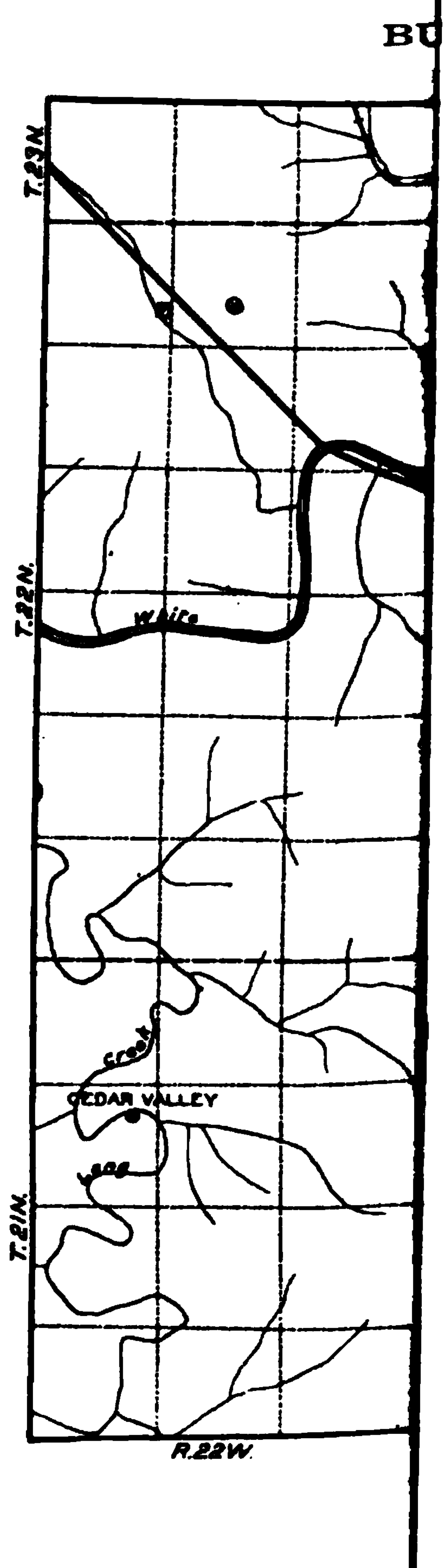
face ledges of the Jefferson City formation which occur in the area. None of the beds have been subjected to leaching, and the only trace of mineral encountered consisted of thin "knife-blades" of galena extending for a short distance along small joints. Owing to the lack of openings and to the density of the beds exposed, there is small likelihood of lead and zinc being encountered in commercial quantities.

BAKER PROSPECT.

The Baker prospect is located two miles south of the village of Drury in the southeastern portion of the county. Here, at the head of a deep, narrow ravine a drift was driven for a distance of 40 feet into a massive bed of crystalline dolomite. The rock has been subject to leaching and, at intervals in the drift, the resulting cavities were found to be partially filled with galena and jack. As indicated by the walls of the drift, however, a majority of these openings are apparently lined only with a thin coating of secondary dolomite, on which frequently occur small crystals of tetra-hedrite. Ten feet from the mouth, a shaft was sunk in the floor of the drift to a depth of 16 feet. Crystalline dolomite, showing the effects of leaching was encountered in this shaft from top to bottom and occasionally a local concentration of galena and jack was found to fill the cavities.

TANEY COUNTY.

The reconnaissance work in Taney county was restricted largely to an examination and tracing of a fractured zone traversing townships 21 and 22 N., in ranges 20, 21 and 22 W. This zone, which is known locally as the "Ten O'clock Run," is well defined, and, as shown on the accompanying map, has an average course striking S. 55° E. It crosses the Stone-Taney county line in Sec. 35, T. 23 N., R. 22 W., running approximately parallel to and on the northeast side of Fall creek until it reaches White river. At this point the fissure disappears in the river channel, which it follows for a little over one mile. It is seen again on the south side of White river in Sec. 18, T. 23 N., R. 21 W. and, striking in practically a straight line across Pine Mountain ridge, enters Arkansas with a course approximately parallel to the valleys of Fox and Bee creeks. This fissure has no apparent relation to the topography; crossing valleys and ridges indiscriminately, and at no place in its course through Taney county does it show evidence of dying out.


BU
T.23N.
T.22N.
T.21N.
White
Creek
CEDAR VALLEY
R.22W.

It has not as yet been traced westward from the Stone-Taney county line.

With the exception of the crest of Pine Mountain ridge, the area traversed by the fissure is underlain by the Jefferson City formation of the Cambrian series.

The Jefferson City is composed of fine grained, white to gray dolomite known as "cotton rock" and heavy massive beds of gray dolomite, which weather to an irregular surface. These beds are well exposed along the "bald knobs" where they usually terrace the hillsides. The Mississippian series underlies the crest of Pine Mountain ridge. Due to a heavy mantle of residual chert and soil, these formations are not well exposed. Where seen, they consist of coarsely crystalline fossiliferous limestone characteristic of the Boone formation.

The zone in which fracturing occurs has a width varying from 400 to 600 feet, within which the surface formation exhibits decided dips and considerable brecciation. The average dip is 10° S. 35° W., although at numerous points considerable variation from this average was noted. Instances of such variation occur on the northwest side of the White river valley where the strata dip 22°, and on the southeast slope of Pine Mountain ridge where locally they were observed to dip 30°.

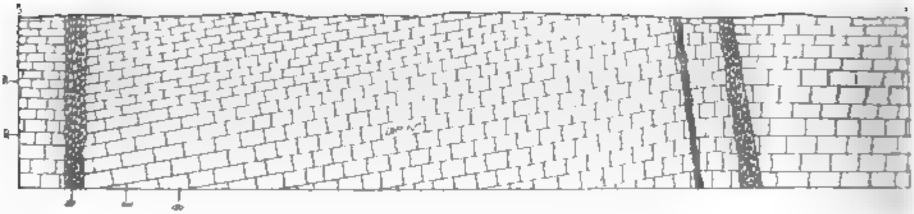
A section across this zone from north to south also shows a variation in the intensity of brecciation. This feature is illustrated in a cut along the St. Louis, Iron Mountain R. R. in Sec. 21, T. 22 N., R. 21 W., and at the Silver Moon mine in Sec. 26, R. 22 N., R. 21 W.

In the railroad cut there is exposed a broken zone having a width of 35 feet, within which the jointing has been so emphasized as to give the rocks a sheeted appearance and has virtually obliterated all evidence of bedding. To the south, this grades into a block of horizontally bedded dolomite having a width of 75 feet, beyond which occurs a narrow zone of brecciation having a width of three feet. From this point the strata dip 10° S. 35° W. towards a ravine, where they become covered with a mantle of residual materials. When next exposed, approximately 450 feet from the first broken zone, the formation is practically horizontal.

At the Silver Moon mine similar conditions occur. A shallow cut normal to the strike exposes two zones of brecciation separated by a block of little disturbed strata having a width of 35 feet. The northern most zone has a width of 15 feet, while the one to the south of the intervening block has a width of three feet. Beyond

the latter, the strata dip 10° S. 35° W. This dip continues for about 200 yards, at which point they abruptly resume their former horizontal position. This resumption of horizontal position is accompanied by a zone of brecciation which is exposed for a width of 10 feet. At this point, it is impossible to determine its exact width, due to a covering of residual materials.

The following cross-section illustrates the above relations:



Section of fractured zone near the Silver Moon shaft.

A number of shafts and test pits have been sunk at various points along this zone and some lead and zinc have been shipped from these prospects. The results of this development work indicate that the lead and zinc ores occur chiefly in the areas of most intense brecciation near the north wall. However, the southern zone described above has not been prospected and may carry ores of both lead and zinc.

At the Silver Moon mine, the shaft has been sunk to a depth of 64 feet, exposing a breccia having a width of 7 feet at the bottom of the shaft, at which point the south side of the shaft entered the unbroken rock or "Horse," as it is called locally. The north wall of the shaft is smooth and illustrates the clean break with which the fissured zone starts. This wall is reported to be coated with a layer of marcasite and pyrite having a thickness of one-fourth of an inch. This layer passes into an eight inch zone of breccia containing coarsely crystalline galena and jack; this, in turn, grades into a zone of about the same thickness in which the ores occur in small crystals. The remainder of this zone, having a width of 5 1-2 feet, becomes less brecciated towards the undisturbed rock and does not run as high in either lead or zinc. Stringers of calcite carrying some lead extend into the so-called "Horse." In this shaft, however, they do not carry sufficient mineral to pay for mining.

At the time this shaft was visited it was half full of water, making an examination impossible. The above succession was re-

ported by Mr. Anderson, who sunk the shaft. Each of these reported types of ore was seen upon the dump.

Similar conditions may be seen at a number of other prospects, although these have not been sunk to as great a depth as the Silver Moon shaft. The depth to which the mineral extends has not been determined at any point. In fact, in most instances, the mineral is reported to have increased with depth.

Oxidation has taken place in the upper part of the fissure, altering the zinc sulphide to the carbonate and corroding the galena slightly. The depth to which this oxidation has extended varies at different points. At the shaft of the Richardson prospect in the N. W. ¼ N. W. ¼ Sec. 20, T. 22 N., R. 21 W., the dump indicates that carbonate ore was encountered throughout the greater part of the entire depth, which was something over 60 feet, while at the Bennett and Leeper shaft the sulphides were noted within a few feet of the surface. Apparently oxidation has extended to an average depth of 20 feet, and in certain localities the fissure may be traced by this ore, which outcrops at the surface. This is true not only at the Richardson prospect but also at the King Solomon workings in the N. E. ¼ Sec. 27, T. 22 N., R. 21 W.

The carbonate ore has either a honey-combed porous texture, or is compact and granular; both types being of commercial grade.

Detailed mapping in this portion of Taney county will probably show additional structural features along which prospecting might be carried on with profit. At a number of points several miles distant from the above fractured zone, the formations show pronounced dipping. The structure, however, has not been worked out, nor detailed mapping undertaken.

The reconnaissance work has not shown the northwest end of the zone, which probably extends a considerable distance into Stone county.

OZARK, HOWELL AND OREGON COUNTIES.

A number of properties and prospects from which carbonate of zinc have been mined were examined in Ozark, Howell and Oregon counties, which border the Arkansas State line. The district included in the above country is apparently a northern extension of the Arkansas field, in which considerable carbonate of zinc is found and from which shipments have been made.

The ore occurs in those portions of the Jefferson City formation that have been subject to extensive leaching and decomposition. Each of the deposits examined is found in the cotton rocks

of the above formation where such decomposition has gone on.

Minable ore has been found at several widely separated points extending from the eastern portion of Ozark county to east of Alton in Oregon county. Systematic prospecting has not been carried on and as similar geologic conditions prevail throughout the entire area, there is every reason to believe that additional deposits of commercial value may be found.

The following brief descriptions indicate the characteristic occurrence of this ore:

ALICE MINE.

This mine, which is owned by the Empire Zinc Company, of Joplin, is located in T. 22 N., R. 11 W. one-fourth of a mile west of Wetherill, Ozark county. It consists of an irregular pit approximately 150 feet square by 40 feet deep.

The ore produced is the carbonate of zinc. It occurs in the Jefferson City formation, which at this point is composed chiefly of fine grained, gray dolomite known as cotton rock.

The opening shows the ore to occur in those portions of the formation which have been subject to leaching and decomposition. In these areas the cotton rock has been wholly or in part replaced by the ore; where replacement has not been complete the carbonate is found filling joints and following the bedding planes. Frequently, where the replacement is complete, the ore preserves the original structure of the dolomite. Two large circular "horses" of practically unaltered dolomite occur in the pit, which run too low in zinc to pay for mining, although some zinc carbonate occurs in fissures and along the bedding planes.

In the upper portion of the deposit and in the over-burden of clay, considerable limonite is found following roughly the original stratification planes. Below a depth of 20 feet it is found less frequently filling joints in the dolomite and decomposed materials.

Six development drifts have been driven from various points in the mine and three 20-foot test pits have been sunk beneath the present mining level. The drifts are reported to have passed through good ground, while the test pits show ore throughout their entire depth. This ore is said to be practically free from limonite. These drifts or test pits were not accessible when the property was visited.

The ore is classified as "gravel" or "coarse," the former constituting that portion which passes a one-inch grizzly. At the time

this mine was visited there were approximately 1800 tons of marketable ore on hand.

C. S. & R. ZINC MINES.

This mine is situated approximately in the center of Oregon county one mile northeast of Alton in the S. W. 1/4 S. E. 1/4 Sec. 27, and the N. W. 1/4 N. E. 1/4 Sec. 34, T. 24 N., R. 4 W. It consists of an oblong shaped pit, 160 by 100 feet in cross-section, and is approximately 20 feet deep.

The deposit occurs in the Jefferson City formation, which, at this point, is composed of characteristic cotton rocks containing an occasional thin bed of chert. The cotton rocks have been decomposed in many places to a soft greyish-yellow clay, under which circumstances the chert beds which remain unaltered have been distorted through settling. Veins of red joint clay are occasionally found in the partly or wholly decomposed cotton rock.

The carbonate of zinc mined from this property was first found in a narrow channel which followed the south and east walls of the above pit. This channel which had a width of from four inches to six feet, was mined before the rock to the north and west was taken out. Throughout this rock the ore occurred in thin plates filling small fissures and bedding planes, and in irregular channels where it had partially replaced the dolomite.

Aside from the zinc carbonate, hydrozincite is commonly found spotting the decomposed cotton rock. It is locally known as "oxide." Considerable limonite is associated with the ore occurring near the surface.

Development work at the mine consists of a 65-foot drift extending beyond the northeast face of the pit, three churn drill holes put down within 150 feet of the east side of the mine, and a test pit approximately 60 feet deep, also located to the east of the mine. Ore is reported to have been found, although neither the shaft nor drift were accessible.

This property has produced approximately 300 tons of carbonate ore which was reported to have run 39 per cent zinc. The ore was hauled 17 miles by wagon to Thayer, the nearest shipping point.

RAGAN ZINC PROSPECT.

This prospect is located one-half mile east of Thayer, Oregon county, in the N. E. 1/4 N. W. 1/4 Sec. 33, T. 22 N., R. 5 W.

Development work, consisting of several open cuts along the

hillslope and one comparatively deep shaft, shows considerable z carbonate filling joints and bedding planes, and replacing the c ton rock. The ore is intimately associated with a large amount limonite, which makes it difficult to obtain a high grade product.

CRAWFORD COUNTY.

In addition to examining a number of deposits of iron o which will be described in the report covering that subject, t work, in Crawford county consisted chiefly of the examination a rapid geologic mapping of a complexly folded and faulted a occurring east of Wesco, in Secs. 16, 17, 18, 19, 20 and 21, T. R. 4 W.

This area is of special economic interest, in that the form tions exposed are the same as those occurring in the Southea Disseminated Lead district of Madison, Washington and St. Fra cois counties. Until discovered this season by assistants of th Bureau, these formations were not known to occur at the surfac in this region, the western most exposures heretofore mapped occurring in the southeastern part of Washington county over 25 miles to the east.

Through the elevation of these lower formations, the area is thought to present geologic features favorable for the occurrence of disseminated ore, and the following notes and maps have been prepared for the purpose of drawing attention to this possible economic development.

The detailed structure of the area has not been worked out and the accompanying sketch is only intended to show the approximate area underlain by the various formations exposed.

As is well known, the disseminated deposits of southeast Missouri occur chiefly in the Bonneterre dolomite where the overlying formations, consisting of the Davis shale and Doe Run, Derby and Potosi dolomites, have been largely removed by erosion. The productive areas have usually shown rich surface diggings, and the occurrence of such ore at what is thought to be the top of the Bonneterre formation in this area may be considered as evidence favoring the possible occurrence of deeper ores.

The following is a brief summary covering the formations observed in the area:

BONNETERRE FORMATION.

At the Metcalf diggings in N. W. ¼ Sec. 17, T. 36, R. 4, a heavy ledge of non-cherty crystalline dolomite is exposed for a short dis-

19

p,
re
ll.
n-
to
r-
e,
ıe

ft
s-
ır
ed
es

ly
ea
ıe
ıe
ıe

e,
ıd
ıe
o-
ds

in
of
th
t.
ıe

et
th
/4

hil
ca
to
lin

wl
w
ra
oc
R.

ti
Di
co
Bu
in
cu
mi

th
of
pr
ec

th
ar

so
fo
Po
pr
oc
Bo
fa

ob

le

tance in the bed of a small creek. A few feet above this outcrop, an old drift driven into the hillside exposed 3 to 4 feet of more thinly bedded chloritic dolomite, dipping sharply into the hill. These beds, which are considered as probable Bonneterre, are immediately overlain by a dark red clay free from chert and similar to that which characterizes the residual soil of the Bonneterre formation in southeastern Missouri. Still higher up the hillslope, numerous pits sunk to depths of from 10 to 12 feet encountered the Davis shale only.

Three hundred yards west of the above diggings a shallow shaft penetrated a small thickness of blue shale and very chloritic crystalline dolomite, both of which are similar to beds occurring near the base of the Davis formation, as exposed in the Disseminated Lead district, and it is probable that the Bonneterre dolomite lies but a few feet beneath the surface at this point.

DAVIS FORMATION.

As shown on the accompanying map, this formation entirely surrounds and is in turn probably entirely surrounded by an area in which exposures of Potosi dolomite and residual chert from the decomposition of this formation occur at the surface. Due to the occurrence of stream deposits along Crooked creek, outcrops of the enclosing belt of Potosi can not be seen along the east side.

The belt of Davis shale, which has a roughly circular outline, varies from 1,200 to 1,700 feet in width between the enclosing and enclosed areas of Potosi. Along the inner edge of this belt the strata exposed dip steeply towards the enclosed area of Potosi dolomite, while on the outer rim the beds have a similar dip towards the enclosing belt.

The formation consists of yellow, green and blue shales; thin intercolated beds of limestone; occasional rather heavy beds of dolomite; and several horizons of edgewise conglomerate, which are identical with those exposed in the southeastern lead district. The central boulder horizon, which forms so striking a datum plane in St. Francois county, was not noted in this area.

DERBY AND DOE RUN FORMATIONS.

These formations, which have a combined thickness of 80 feet in St. Francois county, were not recognized in this region, although an exposure of crystalline dolomite on Crooked creek in S. E. ¼

Sec. 17, T. 36, R. 4, and several outcrops in the outer belt of Potosi may belong to either of these formations. The outcrops observed are not of sufficient extent to warrant correlation.

POTOSI FORMATION.

As already mentioned, the Potosi formation is enclosed by, and in turn encloses, the area underlain by the Davis formation. The enclosed area is roughly circular in shape and has a diameter of approximately 3,300 feet; the enclosing or outer area forms a belt which has an average width of about 400 feet, except in N. E. 1/4 Sec. 17, T. 36, R. 4, where it attains a width of 700 feet. Wherever observed, the beds are found to dip precipitously away from the area of Davis shale.

The formation, as recognized, consists of massive crystalline beds of dolomite containing irregular masses and seams of drusy quartz, which are so characteristic of this formation.

GASCONADE AND ROUBIDOUX FORMATIONS.

These are the surface formations over nearly the entire area of Crawford county, and, in this particular portion, completely surround the area in which the Davis and Potosi formations are exposed.

The Gasconade is composed of characteristic massive beds of crystalline, cherty dolomite, while the Roubidoux is made up of cherty dolomite and sandstone members.

CARBONIFEROUS.

Small outliers of the Carboniferous series occur in N. W. 1/4 Sec. 20, S. W. 1/4 Sec. 21, N. E. 1/4 Sec. 16, and S. E. 1/4 Sec. 20, T. 36 N., R. 4 W. They are composed chiefly of white sandstone, sandy shale, ferruginous clay-shale, flint fire clay, and coal. These deposits are evidently remnants of larger areas which at one time filled the depressions in the uneven surfaces of the underlying formations.

STRUCTURES.

Although the structures of the area were not studied in detail, sufficient information was obtained while traversing the area to account for the presence of the Davis formation approximately 700 feet above its normal position. Everywhere within the region of

Davis-Potosi exposures, the outcrops are characterized by steep dips, the beds often occupying a vertical position. The position of the outcrops and the direction of their dip show the area to be one of sharp folding accompanied by faulting, with folding as the predominant factor. In the enclosed area of Potosi, no dips were noted, bedding planes not being apparent at any point. In the enclosing belt of Davis exposure, the strata dip steeply towards the enclosed Potosi on the inner edge and towards the enclosing belt of Potosi on the outer edge. Wherever bedding planes were apparent in the outer belt of Potosi, the strata were found to dip steeply away from the area in which Davis shale outcrops. On the other hand, exposures of Gasconade and Roubidoux immediately surrounding the outer belt of Potosi are found to dip steeply towards the area in which the Davis-Potosi formations are exposed. And for some distance away from this area the formations have been subjected to much disturbance and the Roubidoux and upper Gasconade occur considerably below their normal elevation in Crawford county. For a distance of a mile or more from the outer exposures of the Potosi, abundant evidences of sharp anticlines and synclines accompanied by minor faulting are furnished by precipitously dipping ledges of both the Gasconade and Roubidoux.

Evidences of faulting occur along nearly the entire south side, at the northeastern corner, and for a short distance along the western border of the area of Potosi-Davis outcrop. In every case the line of faulting occurs between the outer belt of Potosi exposures and the surrounding area in which the Roubidoux and Gasconade formations outcrop.

Along the south line mentioned above, the break between the Potosi and Roubidoux-Gasconade may be traced by boulders of breccia consisting chiefly of broken fragments of drusy quartz. At the other two points, massive boulders of breccia consisting largely of broken chert fragments were noted between the outcrops of the Potosi and Roubidoux-Gasconade.

LEAD.

A considerable quantity of lead ore has been produced in the Metcalf diggings in N. W. ¼ Sec. 17, T. 36, R. 4, where it was found imbedded in the surface clays at the contact of the Bonneterre and Davis formations. These diggings comprise about one acre situated on the north slope of the hill. Within the area the ground has been quite thoroughly worked to a depth of 10 or 12 feet by means

of pits or shallow shafts sunk in close proximity to each other. The amount of lead produced is not known, but it is reported to have been quite large, considering the nature and extent of the mining operations. The citizens of the community state that one massive boulder of galena weighing several thousand pounds was found a few feet beneath the surface near the center of the area. The Bonneterre formation, which carries the disseminated lead deposits in southeast Missouri, forms the base of the hill.

FIRE CLAY.

Deposits of flint fire clay occurring east and southeast of Wesco have been worked intermittently for many years. Of these, the McGary, Scott and Taff clay banks have probably been operated most extensively. In the area mapped, fire clay in small amounts occurs in each of the above mentioned Carboniferous deposits. With a probable exception of the deposit in S. W. ¼ Sec. 21, T. 36, R. 4, where fire clay occurs associated with coal, the deposits are not of sufficient magnitude to warrant working.

The largest known deposit of fire clay occurring in the immediate vicinity of this area is the L. C. Taff bank, located one-half mile west of the outer belt of the Potosi exposures in the W. ½ Sec. 18. Here, the surface over an area about one-half mile square has been prospected to shallow depths by means of pits and drill holes, disclosing the presence of fire clay over practically the entire area. The depth to which the fire clay extends has not, however, been determined. The clay occurs on the crest and higher slopes of a ridge area and is situated in the western edge of the region which has undergone marked disturbance. Roubidoux sandstone comprises the most prominent surface formation, outcrops of which show the effect of folding. Clay has been shipped from this property at intervals for the past several years. The first pit worked is situated on the crest of the ridge and is 60 by 40 feet, with a maximum depth of 10 feet. The walls and floor of the pit show faces of gray flint fire clay overlain near the surface by a small thickness of sandy material. In the southwest corner occurs a small "horse" of sandstone. Recently, a new pit has been opened several hundred feet west of the above, and clay similar in character is being mined and shipped. The overburden at either pit, so far as has been disclosed, is nowhere over two feet in thickness.

On the north side of the ridge and nearly due north of the

above pits an excavation in the east bank of a small ravine shows a five-foot face of white very fine grained fire clay which is said to fulfill the requirements of the so-called china clays.

BARITE.

This mineral commonly known as "ball tiff" has been found in two places. On the east point of a low hill in Sec. 18, T. 36, R. 4, residual barite occurs in clay to a depth of two or three feet. Pits sunk to depths of six or eight feet at this place encountered shale of the Davis formation underlying the thin mantle of clay and barite. A shaft sunk on the south bank of a stream in S. ½ Sec. 17, T. 36, R. 4, disclosed a considerable amount of barite imbedded in clay which filled an opening on which the shaft was sunk.

COAL AND MINERAL WATERS.

Coal occurs associated with fire clay on the low point of a ridge where Mineral Springs Hollow enters the valley of Crooked creek. Here, a pit 15 by 18 feet sunk to a depth of 12 feet shows the following descending section:

0 to 3 feet of soil.
6 feet of bituminous coal of good quality.
4 to 6 ft. dark gray fire clay.

The coal dips at a moderate angle to the southward. The pocket is small, being restricted by surrounding formations and erosion valleys. Apparently no attempt has been made to work the deposit for local consumption.

At the base of the hill immediately beneath the shaft a chalybeate spring issues from beneath a ledge of sandstone. The water of this spring was formerly utilized for medicinal purposes, and at one time a thriving village, located here, was maintained by the patients attracted by the medical properties of the water.

IRON.

Small amounts of both hematite and limonite have been found in different portions of the area. The hematite is confined entirely to the Carboniferous deposits where it occurs in small amounts associated with iron stained chert and ferruginous sandstone. In a Carboniferous deposit on the hillside in S. E. ¼ Sec. 20, T. 36, R. 4, occurred a small amount of specular hematite.

The limonite ore consists of altered sulphide showing excel-

lent pseudomorphs after marcasite. It is apparently confined to a certain horizon in the Potosi and wherever that portion of the formation has been eroded, small masses of the ore occur abundantly in a brownish red clay resulting from the decomposition of the dolomite. The best exposures of this ore occur in the head of the valley in S. E. ¼ Sec. 18, T. 36, R. 4, and near the head of a small ravine in W. ½ Sec. 17, T. 36, R. 4 W.

ı on
ɜ of
t. to
ead.
reau
ɔlete
d in
ex-
uare
·tion
the
ɜults

its
ɾ cut
d its
bor-
ɛe in
New-
evel,
feet.
ı the
bout

Cam-
For-
l the
ɛpre-
face,
from

lent
a ce
form
antly
the
the
smal

NEWBURG DISTRICT.

BY WALLACE LEE.

Geological work in the Newburg district, which is shown on the accompanying map, was undertaken during the months of July and August, 1910, by the St. Louis & San Francisco R. R. to ascertain the most favorable localities in which to drill for lead. The results of this work have since been turned over to this Bureau and the mapping extended with the purpose of issuing a complete report covering the geology of the Rolla quadrangle situated in the western part of Phelps county. The area which has been examined is shown on the accompanying map. It includes 36 square miles in the vicinity of Newburg and occupies the central portion of the Rolla quadrangle. The following brief description of the general geology is published at this time in order that the results may be available in any future development work.

TOPOGRAPHY.

This is a hilly area, drained by Little Piney Creek and its tributaries. There is very little level land, the country being cut up with narrow and deep valleys. The valleys of Little Piney and its tributaries, Mill creek and Kaintuck Hollow have flat bottoms bordered in many places by steep bluffs. The maximum difference in elevation between river bottom and ridge is 314 feet at Newburg. At this place the Little Piney is 705 feet above sea level, while the ridge on the south side has an elevation of 1,019 feet. Approximately the same relative elevations are maintained in the southern part of the area, the Little Piney having a fall of about 10 feet to the mile.

GEOLOGY.

The Gasconade and Roubidoux, belonging to the Upper Cambrian series, are the only formations occurring in the area. Formerly the Pennsylvanian, Mississippian, Ordovician series and the Jefferson City formation of the Cambrian were probably represented. These, however, have been removed, leaving the surface, in many places, strewn with residual material largely derived from the Jefferson City, which was the next overlying formation.

GASCONADE FORMATION.

The Gasconade is the oldest formation in the area, and of this, only the upper 200 feet is exposed. In Miller and Morgan counties where detailed surveys have been made, the entire thickness of 250 to 300 feet is exposed, as well as a portion of the underlying Proctor dolomite.

The Gasconade is composed chiefly of beds of massive gray dolomite and chert, which occurs in the form of beds, 3 to 4 feet in thickness, nodules, and irregular sheets between the dolomite beds. The dolomite is ordinarily coarsely crystalline, although occasional beds from 2 to 4 feet in thickness have a dense finely crystalline texture. The chert beds are usually flat lenses, for which reason they are seldom of uniform thickness over any considerable area. One of these beds, however, is persistent over most of the area. This bed averages about 4 feet in thickness and occurs from 50 to 55 feet from the top of the formation. The upper portion of the bed, about one foot in thickness, is a dense mottled bluish chert containing occasional cavities. The remainder consists of layers of warped and broken, concentrically banded chert, between which are cavities, angular or crescent shaped, lined with quartz crystals and chalcedony. Occasionally these cavities are partly filled with galena and zinc blende, with which is associated some barite.

A few silicified fossils were found in weathered dolomite near the top of the formation, indicating that in part, at least, the chert is secondary.

The following is a typical section of the exposed portion of the Gasconade formation taken from the east side of Poole hollow, near the mouth, in the S. E. ¼ Sec. 23, T. 37, R. 9.

GASCONADE SERIES.

Ft.	
1	Dolomite, coarse grained.
3	Talus.
2	Dolomite, silicious.
1	Talus.
5	Dolomite.
7	Dolomite, pitted, cherty.
5	Dolomite, massive to platy, little chert.
6	Dolomite, pitted.
5	Dolomite, pitted and massive, some chert.
3	Talus.
2	Dolomite, pitted and massive.
4	Dolomite, compact, pitted, somewhat cherty.
1	Talus.
1	Dolomite, coarse grained.
1	Chert, white, dense.
1	Dolomite, cherty.

GASCONADE SERIES—Continued.

Ft.	
4	Dolomite, containing bands of chert about 1 ft. apart.
4	Chert, dense bluish with small cavities at the top; lower three feet banded and warped; contains crescent shaped cavities.
10	Dolomite, massive, thin beds of shattered blueblack chert.
6	Dolomite, very cherty. Chert mottled blue to gray.
2	Chert.
2	Talus.
12	Dolomite, massive, pitted.
8	Dolomite, massive, pitted, little chert.
3	Dolomite, breaks in small blocks.
4	Dolomite, fine, grained, massive.
2	Dolomite, contains chert in layers, increasing at the bottom.
4	Talus.
15	Dolomite, resembles cotton rock. Cherty.
4	Talus.
3	Dolomite, dense, fine grained, massive.

ROUBIDOUX FORMATION.

The Roubidoux formation, which immediately overlies the Gasconade and is conformable with it, consists of two sandstone and two cherty dolomite members. This formation, as well as the underlying Gasconade, dips gently to the north. On the south side of the area the elevation, as indicated by the contact, is 60 feet higher than on the north side.

The upper member of the Roubidoux east of this area is 30 feet thick and consists chiefly of thinly bedded cotton rock underlain by impure, densely crystalline, cherty, dolomite. In the area under consideration these beds occupy the tops of the ridges and are so covered with soil and residual chert that their thickness and general characteristics could not be determined.

Beneath this cherty dolomite is the upper sandstone member, which has a thickness of 25 feet. It is well exposed on most of the ridges, forming low cliffs which are sometimes taken advantage of in fencing the hilltop fields. It has a brownish red color, due to staining with iron oxide, and is comparatively coarse grained. The upper part is more massive, finer grained, and generally of a lighter color than the lower. The upper portion, especially, contains small fragments of chert, which are coarser near the top, giving it almost the appearance of a conglomerate. The upper part of this member is characterized by the presence through weathering of vertical, cylindrical, niche-like cavities one foot to two feet six inches in height, and about one foot in diameter with the base resting on the bedding plane, dividing the upper and lower parts. In places there occurs near the middle of this member a very fine

grained bed varying from 9 to 18 inches in thickness. Upon weathering this splits into very thin plates.

Ripple marks, shrinkage cracks and false bedding are common in this sandstone, especially in the lower portion.

Underneath this sandstone member occurs a horizon of cherty dolomite having a thickness of 35 feet. This member varies greatly in different parts of the area. The cherty layers grade into impure dolomite, and the dolomite often becomes sandy and silicious within short distances. Thin beds of sandstone are also of common occurrence. Certain beds bear a close resemblance to the dolomite of the Gasconade. This member of the Roubidoux weathers easily, for which reason exposures are not common.

Beneath this cherty dolomite is the lower sandstone member, which, while persistent, varies considerably both in thickness and texture. It is normally about 10 feet thick, friable and porous. Where it occurs along the lower hillsides and in the stream beds, it is seldom case hardened, but wherever it caps the lower ridges, removed from erosion, it is case hardened, like the upper sandstone member. When broken, it exhibits fine holes often partly filled with iron oxide, which gives the rock a speckled appearance. The color is similar to, but generally lighter than, the upper sandstone. Although sometimes massive, the beds are generally thin. Outcrops seldom occur except near the crests of the lower ridges and near the heads of steep sloped ravines.

While the normal thickness is ten feet, it is only three feet thick northwest of Newburg. At this place the beds are calcareous near the base and argillaceous near the top. Southwest of Kaintuck hollow in Sec. 16 it has a thickness of 20 feet. In the S. W. 1/4 Sec. 32, T. 37, R. 8, and in the N. E. 1/4 Sec. 17, T. 37, R. 9, the lower six inches is a conglomerate, while just southeast of the area mapped a bed of conglomerate occurs near the middle. False bedding, ripple marks and shrinkage cracks are common.

The grains of quartz sand of which both the upper and lower sandstone members are composed are clear and angular, and in some cases retain to a considerable extent their original crystalline form. Where exposed to the air and away from seepage, both sandstone members become case hardened and resist atmospheric weathering very effectively.

The following sections from the localities indicated, illustrate the changes in the character of the formation:

Ft.	In.	N. E. ¼ SEC. 17, T. 37, R. 9.
8		Dolomite, densely crystalline, fine grained.
9		Talus.
1		Chert, red, gnarled.
1		Talus
1		Chert, bluish to white.
22		Sandstone, massive, brown to reddish brown.
1		Talus.
4		Dolomite, platy, cherty, fine grained, dense.
3		Dolomite, coarse grained, pitted, resembles the Gasconade.
7		Dolomite, fine grained and crystalline, contains angular fragments and plates of chert, thinly bedded. Sandy at bottom.
2	6	Chert, massive to finely shattered, sometimes oolitic.
6		Dolomite, finely crystalline, thinly bedded, cherty.
1		Sandstone, compact, yellow, fine grained, contains minute cavities.
1		Dolomite, irregularly bedded, contains chert layers.
2		Chert, oolitic, color bluish.
5		Talus.
5	6	Sandstone, platy, thinly bedded, contains layers of chert between beds.
	6	Sandstone conglomerate, chert fragments up to one inch in diameter.

On bluff, east side of Little Piney creek, center Sec. 36, T. 37, R. 9.

Ft.	In.	
25		Sandstone, massive, brown and reddish to white coarse grained at bottom to fine at top, cross bedding common
9		Talus.
15		Dolomite, gray, coarsely crystalline, contains small pockets of calcite, weathers to irregular surface and resembles Gasconade dolomite. Near base contains occasional thin flat layers of chert.
2		Talus.
1	3	Chert, mottled blue and white, contains bands of quartz grains and small angular geodes; weathers white.
3		Talus.
1	6	Dolomite, fine grained, contains much chert.
4		Talus.
6	6	Sandstone, white to red, medium to fine grained, massive to thinly bedded.
	6	Dolomite, gray, compact, hard, very sandy. Locally replaced by sandstone.
1		Sandstone, brown to yellowish brown, soft and medium grained.

JEFFERSON CITY FORMATION.

East of this area, the Jefferson City formation rests conformably upon the Roubidoux. At the base, it consists of hard, dense dolomite marked by a network of small cavities filled with finely divided silica, and at the top, of impure gray, fine grained dolomite known as cotton rock. Thin layers of flint occur in this formation. On the higher ridges of this area beneath the mantle of residual material, outliers of the Jefferson City formation may occur.

CAVE CONGLOMERATE.

Patches of sandstone conglomerate consisting of angular fragments of chert and pieces of quartzite with a matrix of sand are associated with most of the sinks in this area, the most notable occurrence being in the vicinity of the Treable creek fault. These

conglomerates have probably been formed in caves and solution channels, as evidenced by the unconsolidated sand containing fragments of chert and sandstone observed on the floor of the Gourd creek cave.

This formation is not usually found in place, although in the S. E. ¼ S. E. ¼ Sec. 31, T. 37, R. 8, it was observed filling a fissure in the Gasconade dolomite. This filled fissure has an average width of two feet and is exposed for a distance of 1,600 feet.

This conglomerate was noted in several localities where all other evidence of sinks or caves has been obliterated. The persistency with which it accompanies present caves and sinks would lead one to conclude that the presence of this material indicates the location of former openings of this character.

STRUCTURES.

The structural features of this district include caves, filled sinks and faulting.

CAVES—The caves occur in the Gasconade dolomites and have been formed by the solvent action of ground water. Near the mouth of Gourd creek there is a large cave having this origin. It is 100 feet wide and 12 feet high at the mouth, the principal chamber extending 185 feet into the hill. Back of this chamber is a tapering gallery several hundred feet long, from which issues a small stream. A bank of bat guano two to four feet thick covers about one-sixth of the area of the cave proper.

Smaller caves occur in the S. E. ¼ Sec. 9, T. 36, R. 9, at the mouth of Vessie branch, and in Poole hollow. In the N. E. ¼ Sec. 16, T. 36, R. 9, a cave has captured the drainage of one of the tributaries of Kaintuck hollow, the water passing through a tunnel 100 feet long and 6 feet high.

FILLED SINKS—Sinks resulting from the enlargement of caves and the falling in or settling of the overlying beds were formed during some previous period of erosion. Later, they were filled by deposits when the land was submerged. The material filling the sinks or caves was afterwards consolidated and more recently, as a result of erosion, the filled sinks have been brought to the surface. They occur not only at the heads of valleys but also on the ridges and uplands, their position apparently bearing no relation to the present surface or underground drainage. Wherever

exposed, the strata which once formed the roof of the cave may be seen dipping at various angles towards a common center.

FAULTING—A zone of normal faulting traverses the middle of the area, beginning in the S. W. ¼ Sec. 27, T. 37, R. 9, and extending southeast to Treable creek.

The principal fault has a maximum down-throw of 100 feet to the south. It begins in the S. W. ¼ Sec. 27, T. 37, R. 9, striking S. 60° E. After a slight bend, as shown on the map, it crosses Little Piney creek and dies out in the N. E. ¼ Sec. 1, T. 36, R. 9. At the first exposure in Sec. 27, and in the north-central part of Sec. 34, the upper Roubidoux sandstone having a displacement of 50 feet is exposed along the fault line. The sandstone at this place has a well developed system of joints striking with the fault and displaying irregular wavy seams of quartzite probably recementing the fractures in the sandstone.

At several places near the center of Sec. 35, the entire thickness of the upper sandstone is exposed south of the fault. The exposures form nearly vertical cliffs, and near the fault the surface is rough and brecciated. The fragments are chiefly angular quartzite with occasional pieces of chert. As a rule, the sandstone contains seams of quartzite, which form pencil-like ridges on the case hardened surface. These ridges cross each other at various angles, making a roughly rhomboidal network. Near the middle of the line between the northeast and southeast quarter sections nearly all of the Roubidoux below the top of the upper sandstone is exposed south of the fault. Along the fault near the top, the rock has been slickensided.

On the end of the ridge in the N. W. ¼ S. W. ¼ Sec. 36, and east of Little Piney creek, the faulting is recognized chiefly by the displacement, there being no conspicuous escarpments.

At the mouth of the ravine draining south between the northeast and northwest quarters of Sec. 35, T. 37, R. 9, the displacement is 60 feet. Approximately 1,200 feet south of the main fault in Sec. 35 there is a zone of distributive faulting, in which occur a number of parallel faults striking N. 58° E. These faults have a down-throw to the north, the displacement varying from 20 to 40 feet.

Faulting was here traced to the east as far as Mill Dam hollow and to the west as far as the central part of the S. W. ¼ Sec. 35. These faults are not persistent. In places they overlap each other, resembling step faulting, and here as well as farther to the west,

part of the displacement has been relieved by dip. The exposures are characterized by quartzite seams and jointing parallel to the strike.

Two small faults occur 500 feet apart on the bluff on the east side of Little Piney creek in the south-central part of Sec. 36. The area between these faults has been dropped about 20 feet. The escarpments are on the upthrow sides and are accompanied by the usual brecciation and quartzite seams. The faults dip toward each other at an angle of 20°. In the same section north and northeast from here, there are a number of faults of too little importance to be shown on the map.

On the southwest side of Treable creek, in the S. W. 1/4 Sec. 31, there is a fault having a down-throw of 60 feet to the northeast and striking S. 55° E. From this place the fault can be followed about 1 1/4 miles to the N. E. 1/4 Sec. 6, T. 36, R. 8, where it disappears beneath the delritus of the valley. There are no well defined escarpments, although the fault plane is clearly exposed near the mouths of the valleys and on the points of the ridges.

Indications of another fault are found on the east side of Treable creek, but the actual line of faulting was not determined. At the base of the ridge near the road in the S. W. 1/4 N. E. 1/4 Sec. 6, T. 36, R. 8, the contact of the lower sandstone with the Gasconade is 40 feet below its normal position. The fault line passes between this point and the top of the ridge immediately east, where the upper sandstone is found at the correct elevation.

IRON.

Iron ore is found associated with the filled sinks already described. From three of the sinks shown on the map, iron ore has been mined; these are, the Hudgeons bank, in Sec. 36, T. 37, R. 9, the Kelly No. 1, in Sec. 18, T. 36, R. 8, and the Buckland bank, in Sec. 20, T. 37, R. 8. The Moselle No. 10, in Sec. 20, T. 36, R. 8, is just outside of the area mapped. These deposits of iron ore were all opened forty years ago, and from them several thousand tons of ore were shipped.

The Moselle bank No. 10 is located on a small tributary of Gourd creek. The sink is apparently small. The ore is in part specular hematite and in part red hematite, ochre and limonite.

Kelly No. 1 bank is on the ridge north of Gourd creek. The ore is mainly red hematite, with which occurs some specular hematite.

The Buckland is a small deposit situated near the railroad. The ore consists of specular and red hematite.

It is possible that iron ore exists in other sinks in this area, and while it is recognized that filled sink structures do not always contain iron ore, they present the best localities in this district for prospecting.

LEAD AND ZINC.

Galena has been found in Phelps and adjoining counties for many years. The early settlers gathered it from the stream bottoms and smelted it into lead for bullets. A great many shallow test pits have been sunk in this area and in recent years prospecting has been carried on by sinking shafts and drilling. In a number of localities in the residual clay, near the contact of the Gasconade and Roubidoux formation, galena has been found in aggregates of crystals, commonly called "cog" ore. This is sometimes associated with barite and less often with zinc blende. These minerals originally occurred in the joints and solution cavities of the once overlying beds. The disintegration of these beds and the removal of the less stable minerals, has resulted in the concentration of the galena, barite and zinc blende in the residual clays. Lead also occurs in cracks and cavities in the chert beds of the Gasconade, particularly in those about 50 feet from the top of the formation. It appears to be more abundant where the beds are broken with numerous joints, especially near the surface. Zinc blende and galena also occurs in vugs and small solution cavities at some places in the dolomite beneath the brecciated chert.

The above brief outline of the geology of the Newburg district indicates the formations underlying the area, and those structures which may have been instrumental in directing the circulation of ground waters. The introduction of mineral bearing solutions in the lower portion of the Gasconade will depend largely upon the openings in the formation. Such avenues of circulation are probably afforded by the zones of faulting and deeper sinks and the area contiguous to such structures is considered the most favorable for deep prospecting.

The following companies have been engaged prospecting in the Newburg district during the past year.

The Little Piney Mining and Drilling Co.

J. B. Holman and Alexander Bros.

The Newburg Mining and Development Co.

CHEMICAL ANALYSES.

During the past biennial period the Department has received many specimens and samples requiring chemical tests or complete analyses to determine their commercial value. Samples collected by the members of the survey Staff have also been analyzed, the results being published in the reports of the Department.

The following include a number of complete analyses of clays, ores and mineral waters received from different localities. There are no special reports in preparation covering the areas from which they were obtained.

CLAYS.

(1)

Samples of drill cuttings taken from an undeveloped flint fire clay bank located just east of the Frisco railroad north of Rolla, Phelps county, on property owned by Mr. D. Cowen. This deposit is reported to have been drilled to a depth of 100 feet. The clay, as taken from a 30-foot shaft, carries considerable sand, and has a light, gray color.

		No. 1.	No. 2.
Moisture	(—105°)	0.65%	0.98%
Moisture	+105°)	11.49	12.27
Silica	SiO_2)	50.42	45.09
Iron Oxide	(Fe_2O_3)	0.73	0.87
Alumina	(Al_2O_3)	35.64	38.67
Lime	(CaO)	0.32	0.17
Magnesia	(MgO)	0.00	0.00
Total		99.25%	98.05%

Sample No. 1, 20 to 28 feet beneath surface.
Sample No. 2, 40 to 48 feet beneath surface.

(2)

Fire clay taken from near the bottom of the pit of the Fulton Fire Brick Company of Fulton, Mo.

Moisture	(—105°)	1.29
Moisture	(+105°)	9.71
Silica	(SiO_2)	55.32
Iron Oxide	(Fe_2O_3)	1.13
Alumina	(Al_2O_3)	30.26
Lime	(CaO)	0.20
Magnesia	(MgO)	trace
Titanium Oxide	(TiO_2)	1.52
Total		99.43

(3)

Samples of shale obtained from undeveloped outcrops occurring southwest of Nevada on land owned by J. P. Stephenson. The shale has been subject to weathering.

		No. 1.	No. 2.
Moisture	(—105°)	1.21	1.28
Moisture	(+105°)	8.31	4.56
Silica	(SiO_2)	54.02	75.16
Iron Oxide	(Fe_2O_3)	5.25	3.32
Alumina	(Al_2O_3)	26.59	13.29
Lime	(CaO)	0.47	0.24
Magnesia	(MgO)	trace	trace
Potash	(K_2O)	1.49	0.94
Soda	(Na_2O)	2.69	1.70
Total		100.03	100.49

No. 1 upper shale.

No. 2 lower shale separated from No. 1 by 5-inch seam of coal.

(4)

Sample of fire clay obtained from M. E. Pugh, Carrington, Mo.

Moisture	(—105°)	6.30
Moisture	(+105°)	6.11
Silica	(SiO_2)	61.31
Iron Oxide	(Fe_2O_3)	4.42
Alumina	(Al_2O_3)	19.68
Lime	(CaO)	0.40
Magnesia	(MgO)	1.85
Total		100.07

(5)

Sample of white kaolin from Perry county.

Moisture		14.00
Silica	(SiO_2)	44.99
Iron Oxide	(Fe_2O_3)	0.61
Alumina	(Al_2O_3)	40.19
Lime	(CaO)	none
Magnesia	(MgO)	none
Total		99.79

(6)

Samples of clay received from M. E. Pugh, Carrington, Mo.

		No. 1.	No. 2.
Moisture	(—105°)	6.30	0.73
Moisture	(+105°)	6.11	9.33
Silica	(SiO_2)	61.31	57.93
Iron Oxide	(Fe_2O_3)	4.42	2.69
Alumina	(Al_2O_3)	19.68	27.02
Lime	(CaO)	0.40	trace
Magnesia	(MgO)	1.85	0.87
Total		100.07	98.57

Sample No. 1 taken from bed of fire clay occurring underneath coal.

Sample No. 2 white fire clay from near Carrington.

(7)

White kaolin obtained from John Bartholomaeus at Warrenton, Mo.

Moisture	(—105°)	1.40
Moisture	(+105°)	12.29
Silica	(SiO_2)	43.42
Iron Oxide	(Fe_2O_3)	0.54
Alumina	(Al_2O_3)	39.65
Lime	(CaO)	none
Magnesia	(MgO)	0.85
Total		98.15

(8)

Surface clay submitted by the Centralia Development Co., Centralia, Mo. This clay is apparently of glacial origin.

Moisture	(+110°)	5.09
Silica	(SiO_2)	70.36
Iron Oxide	(Fe_2O_3)	3.27
Alumina	(Al_2O_3)	13.16
Lime	(CaO)	0.90
Magnesia	(MgO)	0.94
Alkalies		Undetermined
Total		93.72

(9)

Sample of white flint fireclay from near Wesco, Crawford Co.

Moisture	(at 105)	.57
Moisture	(+105)	4.23
Silica	(SiO_2)	78.25
Iron Oxide	(Fe_2O_3)	none
Alumina	(Al_2O_3)	14.88
Lime	(CaO)	trace
Magnesia	(MgO)	.696
Hf. residue		.39
Total		99.016

Partial analysis of fire clay obtained from Chadwick, Mo.

Silica	(SiO_2)	81.99
Iron Oxide	(Fe_2O_3)	11.35
Alumina	(Al_2O_3)	
Lime	(CaO)	none
Magnesia	(MgO)	0.35
Total		93.69

MINERAL WATERS.

(10)

Samples of water obtained from the R. D. Silver well, located two miles north of St. Peters in St. Charles county. The well has a strong artesian flow and is so cased that the water is obtained through two pipes from the upper and lower portions of the well.

		Grains per gallon. No. 1	No. 2.
Silica	(SiO_2)	0.5140	0.5255
Iron Oxide	(Fe_2O_3)	0.0351	0.0292
Calcium Sulphate	($CaSO_4$)	19.8100	38.5000
Calcium Carbonate	($CaCO_3$)	2.2380	0.4322
Magnesium Chloride	($MgCl_2$)	....	52.3100
Magnesium Carbonate	($MgCO_3$)	11.5700	1.6240
Potassium Chloride	(KCl)	19.1600	75.4100
Sodium Chloride	($NaCl$)	91.8300	259.8000
Totals		145.1571	428.6309

(1) Sample to 1100 feet in depth.
(2) From 1100 to bottom of well.

(11)

Water obtained from a deep well drilled at Hall's Station, Buchanan county.

		Grains per gal.
Silica	(SiO_2)	0.56
Iron Oxide	(Fe_2O_3)	0.105
Calcium Sulphate	($CaSO_4$)	0.284
Calcium Chloride	($CaCl_2$)	19.89
Magnesium Chloride	($Mg.Cl_2$)	20.59
Sodium Chloride	($NaCl$)	818.50
Total		859.929

TRIPOLI.

(12)

Sample of tripoli obtained from the shaft of the Little Piney Mining & Development Co., located near Newburg, Phelps county. The sample contained particles of undecomposed chert.

Moisture	(+105)	1.00
Silica	(SiO_2)	96.02
Iron Oxide	(Fe_2O_3)	1.76
Alumina	(Al_2O_3)	
Lime	(CaO)	0.52
Total		99.30

(13)

Sample of Ochre obtained from I. C. Pirtle of Fredericktown, Madison county.

Moisture	(—105°)	4.23
Moisture	(+105°)	12.46
Silica	(SiO_2)	12.97
Iron Oxide	(Fe_2O_3)	62.63
Alumina	(Al_2O_3)	5.58
Lime	(CaO)	0.08
Magnesia	(MgO)	0.77
Sulphur	(S)	0.12
Total		98.84

COAL.

(14)

Bituminous coal obtained from bed located south of Sullivan, Crawford county. The coal occurs at a depth of 164 feet.

	1)	(2)
Moisture	2.66	0.86
Volatile Hydrocarbons	37.53	......
Fixed carbon	52.15	89.01
Ash	7.66	10.13
Total	100.00	100.00
Sulphur	3.16	1.45

No. 1 sample of coal.

No. 2 coke burned from this coal.

IRON ORE.—(CARBONATE.)

(15)

Sample obtained at New Cambria, Missouri, from a shaft 130 feet in depth. Ore mixed with chert nodules in shaft.

Silica	(SiO_2)	30.53
Calcium Carbonate	($CaCO_3$)	3.44
Magnesium Carbonate	($MgCO_3$)	1.73
Alumina	(Al_2O_3)	1.90
Iron Oxide	(Fe_2O_3)	5.46
Ferrous Carbonate	($FeCO_3$)	55.00
Total		98.06

(16)

The following are analyses of limestones from various formations:

		No. 1	No. 2	No. 3	No. 4
Moisture	(H_2O)	0.07	....	....	0.03
Insoluble		3.21	8.35	3.75	3.02
Iron Oxide / Alumina	(Fe_2O_3) / (Al_2O_3)	1.80	1.73	3.23	1.24
Calcium Carbonate	($CaCO_3$)	90.12	78.13	92.53	67.95
Magnesium Carbonate	($MgCO_3$)	5.19	10.09	1.70	27.48
Totals		100.39	98.30	101.21	99.72

(1) Oolitic limestone, Burges quarry, Kansas City, Mo.

(2) Drum limestone (Bull ledge) Flannagan quarry, Kansas City, Mo.

(3) Drum limestone (Bull ledge) Lyle quarry, Kansas City, Mo.

(4) Gasconade dolomite, Newburg, Phelps county.

	December.			Total.		
	1909	1910				
y.	Exps.	Salary.	Exps.	Salary.	Expenses.	
.00	$52.73	$250.00	$100.84	$6,000.00	$1,421.78	
.00	56.84	125.00		2,125.00	527.54	
.00	18.25	90.00	94.00	1,149.00	543.42	
.00		65.00		1,090.00	263.05	
		80.00	13.65	708.00	547.82	
.00		20.00		480.00		
				250.00	77.92	
		20.00	2.25	301.66	97.22	
				197.70		
		50.00	79.10	175.00	220.00	
				25.00	24.56	
				25.00	41.02	
				110.00	194.29	
		52.50	122.57	105.00	206.67	
				63.00		
.00	26.79			521.18	126.78	
		50.00		410.00		
					392.32	
		50.00		350.00	566.55	
	90.48		259.96		2,392.21	
.00	$245.09	$852.50	$672.37	$14,085.54	$7,643.15	$21,728.69

Hugh Stephens Printing Co.		2,672.53
Expenses of board		190.34
Total		$24,591.56
$31.58 ... $580.14	$9,923.44	
Hugh Stephens Printing Co.	400.44	
	$10,323.88	10,323.88
Total		$34,815.44

MISSOURI BUREAU OF GEOLOGY AND MINES.

H. A. BUEHLER, Director and State Geologist

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

TO THE

Forty-Seventh General Assembly

THE HUGH STEPHENS PRINTING COMPANY,
JEFFERSON CITY, MO.

MISSOURI BUREAU OF GEOLOGY AND MINES.
H. A. BUEHLER, Director and State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

TO THE

Forty-Seventh General Assembly

THE HUGH STEPHENS PRINTING COMPANY,
JEFFERSON CITY, MO.

RESOLUTION.

WHEREAS, His excellency, the Governor, has by his private secretary, transmitted to the House the biennial report of the Bureau of Geology and Mines; therefore, be it

Resolved, That 1,500 copies, the usual number, be printed for the use of the members of this House and the Bureau of Geology.

OMAR D. GRAY, Chief Clerk.

Resolved, That one thousand (1,000) copies of the biennial report of the Bureau of Geology and Mines be printed for the use of the Senate and the State Geologist.

J. J. DIMMITT, Asst. Secretary.

TABLE OF CONTENTS.

BOARD OF MANAGERS.

His Excellency, Herbert S. Hadley, Governor of Missouri, Ex-Officio President of the Board, Jefferson City.

Hon. Philip N. Moore, Vice President, St. Louis.

Hon. S. Duffield Mitchell, Secretary, Carthage.

Hon. John H. Bovard, Kansas City.

Hon. Elias S. Gatch, St. Louis.

LETTER OF TRANSMITTAL.

To His Excellency, Governor Herbert S. Hadley and the Honorable Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to transmit herewith a brief report covering the work of the Bureau of Geology and Mines during the past biennial period.

The present importance of the mineral industries, as well as their phenomenal growth during the past fourteen years, is indicated by the total value of the output which has increased from $13,325,000 in 1898 to more than $45,450,000 in 1911. The production for 1912 will exceed $50,000,000.

The demands on the Bureau have greatly increased during this period and, in order to be of the greatest assistance to the future development of these industries, the work of the Survey should be so extended as to meet the requirements of the new problems involved.

Respectfully submitted,

H. A. BUEHLER.

CHAPTER I.

WORK OF THE BUREAU OF GEOLOGY AND MINES DURING 1911 AND 1912.

During the past biennial period the investigations of the Bureau of Geology and Mines have been directed to a study of those geologic factors bearing directly upon the economic prospecting and development of the metallic and non-metallic resources of the State.

Every geologic formation contains deposits of commercial value. One may contain ores of lead and zinc; a second, iron ore; while a third may have valuable deposits of clays, stone, or coal. These deposits do not occur accidentally, but each is directly related to certain geologic conditions which determine the location, size, and richness of the ore bodies. A knowledge of these geologic factors will, therefore, greatly assist in the systematic development of the mineral resources of the State. It is the strict province of this Bureau to make a study of these relations and publish the results in the form of reports and maps for the use of land owners, miners, engineers, and investors.

IMPORTANCE OF MISSOURI'S MINERAL RESOURCES.

Missouri is today one of the chief mining states of the Union, ranking ninth in the value of her mineral output. The production of her lead and zinc mines alone exceed in value the output of gold in Colorado, California, Nevada or Alaska. The vast extent and value of the mineral industries is shown by the following table:

MINERAL PRODUCTION FOR 1898 AND 1910.

Commodity.	1898.	1910.	Per cent increase.
Lead	$3,011,055	$11,286,750	275
Zinc	2,927,321	9,903,942	238
Clay and clay products	3,256,207	7,597,199	133
Coal	3,148,826	5,814,381	85
Cement (portland)	None.	3,858,088	....
Building stone	437,874	2,520,665	475
Mineral paints	No data.	1,808,872	....
Sand and gravel	No data.	1,343,679	....
Lime	297,401	846,143	185
Iron ore	123,345	168,697	37
Mineral waters	59,341	96,488	63
Tripoli	No data.	71,978	....
Barytes	61,875	85,624	35
Silver	None.	17,872	....
Oil and gas	None.	15,111	....
Copper	None.	11,955	....
Totals	$13,323,245	$45,447,444	241

The above figures indicate the rapid development of practically all of the mineral resources during the past decade. Virtually, all of the important mineral industries have more than doubled in output during this period. In the case of building stones the increase has been 475 per cent; lead has increased 275 per cent, and zinc more than 230 per cent. In no case has there been a decrease in production.

The increase in the past decade is a criterion of the undeveloped condition of the mineral resources and what the future output may be.

The mineral deposits are not confined to any particular portion of the State but occur in almost every county. The metallic ores are found chiefly in the Ozark region while the non-metallics occur largely in the northern, eastern, and western portions of the State. The following statement indicates the variety and wide distribution of the mineral resources:

Lead Ore.—The most extensive deposits of lead ore in the world occur in St. Francois, Washington, and Madison counties. Fissure deposits are found in Franklin and adjoining counties. Irregular deposits throughout the Central Ozarks and extensive ore bodies are mined in the Joplin district of southwest Missouri.

Zinc Ore.—The Joplin district of Jasper, Lawrence, and Newton counties contains the most extensive deposits of zinc ore in the United States. Carbonate of zinc is found in the southern Ozarks; sulphides in the central Ozarks and Jefferson county.

Barytes.—Missouri produces 50 per cent of the barytes mined in the United States. The output is obtained chiefly in Washington, Jefferson, Franklin, Miller, Morgan, and other Central Missouri counties.

Iron Ore.—Several types of iron ore are found throughout the southern portion of the State. Specular ores in porphyry in St. Francois and Iron counties; high grade red ores in Phelps, Dent, Crawford, Franklin, and adjoining counties; brown ores in Wayne, Butler, Ripley, Shannon, Howell, Oregon, and other counties of southeast Missouri and in Greene and Lawrence counties of southwest Missouri.

Copper.—Several of the geological formations of south Missouri carry copper ore. Found in Ste. Genevieve, Madison, Shannon, Dent, and adjoining areas. The industry is virtually undeveloped.

Cobalt and Nickel.—Extensive deposits occur in Madison county. Ores of these metals are associated with copper and lead.

Tungsten.—Ores of tungsten found in Iron county; undeveloped.

Coal.—Deposits occur from Iowa to Kansas state line. Beds vary from 1 to 6 feet in thickness; Coal Measures cover 25,000 square miles of the northern and western portions of the State.

Clay Industries.—Commercial clays occur in almost every county. Chinaware clay in southeast Missouri; flint fire clay in central Missouri; plastic fire clay in St. Louis and northern Missouri; shales in northern and western Missouri; potters clay in southwest Missouri; brick clay along the Missouri and Mississippi rivers.

Limestone.—Noted deposits at Carthage and Phenix in Jasper and Greene counties. Formations wide spread.

Sandstone.—Produced chiefly near Warrensburg in Johnson County.

Granite.—Occurs in Iron, Madison, St. Francois, and adjoining counties.

Portland Cement.—Large plants in the eastern, southeastern, and western portions of the State. Suitable materials widely distributed throughout north and east parts of State.

Lime.—Important industry in southwest, northeast, and southeast portions of the State. Missouri largest producer west of the Mississippi river.

Tripoli.—Produced chiefly in Newton county, used for polishing powder and filters.

Oil and Gas.—Shallow deposits in Jackson and adjoining counties.

Sand.—Important deposits of glass sand found in the eastern portion of the State, extending from Callaway to Cape Girardeau county.

Mineral Waters.—Mineral waters are widely distributed throughout the State.

The sketch map on the opposite page better illustrates the wide distribution of our mineral resources, many of which are but partially developed.

The Bureau of Geology and Mines is the only department maintained by the State through which accurate knowledge of the occurrence and development of these deposits can be obtained. The Survey is devoting its entire time to a study of the rational devel-

opment of the various mineral resources; the results being published in reports which are distributed to land owners and others interested in the mining industry.

The following assistants have constituted the permanent staff of the Bureau during the past biennial period:

H. A. Buehler, State Geologist.
V. H. Hughes, Assistant State Geologist.
G. W. Crane, Geologist.
F. C. Greene, Geologist.
Wallace Lee, Geologist.
M. M. Albertson, Assistant Geologist.
A. X. Illinski, Chemist.

Miss E. E. Hirdler, chief cerk, Miss Gertrude Stimson, stenographer, and Wm. E. Morse, janitor, have been employed at the office.

In addition to the above, a number of temporary assistants have been employed during the summer months. Mr. Henry Hinds of the Federal Geological Survey was engaged on the co-operative coal work during a large part of the period.

The topographic mapping, which is done in co-operation with United States Geological Survey, was in charge of Mr. W. H. Herron, Geographer for the north-central division. The quadrangles to be mapped were designated by the Board of Managers of the State Survey.

This Bureau has been in close touch with the Federal Geological Survey and has enjoyed more extensive co-operation than during any previous biennial period. The Federal Survey expended approximately $25,000 in Missouri during 1911 and 1912. These co-operative expenditures were made in a study of the (1) coal deposits; (2) stratigraphy of northwest Missouri; (3) topographic mapping; and (4) in the collection of statistics.

We have also been in conference and visited the mining districts with Mr. C. E. Wright of the United States Bureau of Mines. Mr. Wright is studying the milling and mining methods of the Joplin zinc fields for the Federal Bureau.

Co-operation with the Federal Bureaus should continue since through such united efforts the duplication of work is avoided and the publication of results is greatly facilitated.

Among the more important investigations carried on during the past biennial period are the following:

COAL DEPOSITS.

In co-operation with the Federal Geological Survey the Bureau completed a detailed study of the coal deposits. This investigation embraced most of the northern and western portions of the State; the Coal Measures occupying approximately 25,000 square miles. This is the first detailed investigation ever made of the Missouri coals.

The report, embracing the results of this work, includes chapters on (1) the Coal Measures in Missouri, showing the distribution of the formations throughout the State; (2) the mode of occurrence of coal in Missouri, including a discussion of the various coal beds and coal pockets, as well as showing the present productive fields; (3) the coal industry, a discussion of production and markets, the value of the coal lands, and the tonnage of each county; (4) a detailed description of the coal deposits in each county; (5) chemical analyses of Missouri coals; and (6) boiler tests of Missouri coals. The last chapters show the fuel values of each seam in each productive district. The analyses have been made under uniform methods employed by the Federal Bureaus and are comparable in every way with those made by the Government in other fields throughout the United States.

The individual areal descriptions cover 67 counties, each of which show in detail the occurrence of the coal beds and the geologic conditions under which the various beds are found, as well as the depth below which it is useless to prospect for coal.

The results show that several of the coal seams underlie extensive areas, in some cases extending from the Iowa to the Kansas state lines. A considerable portion of the production of the State being obtained from veins having a thickness of 16 to 20 inches, one of the thinnest veins mined in the country.

The report is the first comprehensive exposition of the coal deposits of the State.

IRON ORES.

The iron bearing region of Missouri lies chiefly within the Ozark plateau and covers approximately 30,000 square miles or half the area of the State. Within this region there are several types of iron ore, each of which differs radically from the others. In order to indicate the distribution, mode of occurrence and value of the deposits, the Bureau has recently completed a detailed investi-

gation and issued a report covering our present knowledge of these ores. As shown by this volume, Missouri has produced approximately 10,000,000 tons, and still contains a vast undeveloped tonnage of ore available under present commercial conditions. The more important types are located as follows:

(1) *Specular ores in porphyry.*—This type of deposit is restricted to porphyry region of southeast Missouri, chiefly in Iron and St. Francoise counties.

(2) *Red ores of Central Missouri.*—These deposits occur chiefly throughout the Central Ozarks in Phelps, Dent, Crawford, Franklin, and adjoining counties.

(3) *Brown ores.*—Found chiefly in southwest and southeast Missouri; practically undeveloped.

(4) *Red ores of the Coal Measures.*—Undeveloped deposits found in the Coal Measures bordering the Ozark region.

The report shows in detail the physical and chemical character of each type of ore and the areas in which it may be found. Particular attention has been devoted to the brown ores which have hitherto remained practically undeveloped. These deposits are shown to contain ores equal in value to those produced so extensively in other southern states; they were formerly considered of too low grade to be utilized. As these ores occur at the surface mixed with residual clay they can be worked with comparatively inexpensive equipment.

Although Pilot Knob and Iron Mountain have been operated in a small way during the past decade the report indicates that they contain a larger reserve than any developed deposit in the State.

The red ores of the Central Ozarks are shown to occur in peculiar sink structures which may be determined in most cases by a detailed surface examination. Prospecting should be restricted to areas showing this geologic feature.

The report gives chemical analyses of each type, indicating their respective values. The detail of the investigation may be realized through the fact that over 800 deposits are described under county headings; every known deposit is given a brief description.

LEAD AND ZINC DEPOSITS.

Within the past few years the Bureau has issued reports covering the Disseminated Lead Deposits of Washington and St. Fran-

cois counties of southeast Missouri and the Granby area of southwest Missouri. These reports show the geologic conditions under which the ores occur over a part of the lead and zinc bearing areas. During the past biennial period work has been continued in southwest Missouri. Approximately 550 square miles of zinc bearing territory, extending from east of Carthage to Marionville, have been mapped.

This quadrangle, which includes portions of Jasper, Newton, Barry, and Lawrence counties, embraces the mining camps of Aurora, Wentworth, Sarcoxie, Reeds, and Stotts City. Mining has been restricted to the immediate neighborhood of the above cities. The entire territory is potential mining ground as shown by recent drilling which has extended the limits of some of these camps.

The commercial ore bodies are closely related to certain geologic features which are well shown on the maps. In addition to a discussion of the geology, the report will include a detailed description of the mines operated in each camp.

GLASS SAND.

The eastern portion of the State contains deposits of white sand suitable for making the finest grade of plate glass. This sand is obtained from the St. Peters sandstone known as the "Pacific". This formation, which is extensively quarried at Pacific and Crystal City, is well exposed in Lincoln, Pike, Callaway, Montgomery, Warren, and St. Clair counties north of the Missouri river, and in St. Louis, Jefferson, Ste. Genevieve, Perry, and Cape Girardeau counties to the south. In order to show the distribution, thickness, and general character of this sandstone, mapping has been started and a detailed study is being made of the entire area. Before the report is published, sandstones occurring in other formations will be studied, although these usually carry too much iron to be available in the manufacture of high grade glass.

AREAL REPORTS.

During the past few years the Bureau has published areal reports covering Miller, Morgan, Moniteau, and Pike counties and detailed maps published in other reports include parts of Newton, Washington, St. Francois, and Crawford counties. During the past biennial period mapping has been completed and reports will be

issued covering counties and quadrangles located in both north and south Missouri.

Mapping has been completed in the following areas during the biennial period:

Jackson County.—The geology of Jackson county has been studied and detailed maps have been published both of the county and Kansas City; the former on a scale of one mile to the inch, the latter on a scale of two miles to the inch. The report is ready for publication.

There are several geologic formations in Jackson county each of which has distinct characteristics and economic possibilities. The maps indicate accurately the distribution of each formation. In Kansas City where the nature of the sub-surface strata is of the greatest importance in all structural and other engineering problems the maps will be of the greatest value in showing just what formations will be encountered with depth. As the formations are usually less than 20 feet in thickness and vary from hard limestone to soft shale this knowledge is of the utmost importance.

The mineral resources are chiefly clay, shale, and building stone and the commercial adaptability of each has been investigated through laboratory tests. Chemical analyses and burning tests have been made of the clays and shales occurring in each formation. The limestones have been analyzed in order to determine their adaptability for use in the manufacture of Portland cement.

Rolla Quadrangle.—The Rolla quadrangle in Phelps county consisting of approximately 225 square miles has been mapped and the report is ready for publication. The area is typical of the Central Ozark region and this work will form the basis for future investigations throughout the same region. The report will also indicate the economic resources of the quadrangle showing the occurrence of iron, lead, zinc, fire clay, and other mineral resources.

Green and Queen City Quadrangles.—A study of the lower Coal Measures has been made in the northern portion of the State in Putnam and Schuyler counties. Mapping has been completed over an area of 500 square miles, including the important coal mining camps of Stahl and Connelsville. The study indicates that the coal resources of the area are much more extensive than heretofore supposed.

Leavenworth and Mecca Quadrangles.—The area of the Leavenworth and Mecca quadrangles, including almost all of Platte and

the western portion of Clay counties, has been mapped in detail. This area includes a detailed study of the formations of the upper Coal Measures, and of the area underlain by the Leavenworth coal seam.

CHEMICAL WORK.

The Survey is continually receiving requests for the examination of rocks, clays, mineral waters, and minerals from citizens throughout the State. There are also numerous specimens and samples of ore obtained by members of the staff which require chemical analyses and assaying. In order to do this work the Survey has maintained a small chemical laboratory and a number of the analyses made during the past biennial period are given in the latter part of this report. Chemical experiments have also been carried on for the purpose of determining the source and the concentration of the lead and zinc ores of the State. This investigation is of scientific and practical importance as it has a direct bearing upon the method of concentration of our workable ore bodies.

LIBRARY AND MUSEUM.

Through a system of exchange enjoyed with other Geological Surveys and scientific institutions the Bureau has established a reference library for the use of its staff. The reports are obtained without cost and are of the greatest importance for reference and study. During the past biennial period approximately 300 volumes have been obtained through this means.

In order to show the extent and importance of the various mineral resources of the State the Bureau also maintains a Geological Museum consisting of ores, rocks, and fossils, obtained from the various formations of the State. These specimens are valuable for comparative purposes for members of the Survey staff and are available for study by any citizen who may desire a knowledge of the workable ores of the State.

The Director of the Bureau has been placed in charge of the Department of Mining and Forestry at the State Fair, and a representative collection of the rocks and minerals of the State has been placed on exhibit at Sedalia.

Numerous inquiries for representative specimens of the various ores and rocks occurring throughout the State are continually received from teachers and educators. A complete collection of such

specimens would prove of the greatest value for instructional purposes and one or more sets illustrating Missouri's economic resources should be placed in every High School in the State. To this end we have started the collection of a considerable quantity of material which will be worked up into suitable collections for educational purposes.

TOPOGRAPHIC MAPPING.

Under terms of co-operation with the United States Geological Survey topographic mapping has been carried on in the northern and western portions of the State. The Federal Survey not only pays one-half of the total field expenses but provides its trained corps of assistants and does all necessary engraving without cost to the State. Electrotypes are furnished the State Bureau without charge. The work is under the direct supervision of Mr. W. H. Herron, Geographer of the Federal Survey and the areas to be mapped are designated by the Board of Managers of this Bureau.

The topographic maps obtained through this co-operative agreement are based upon accurate field surveys and are the only system of accurate maps being published. On the accompanying diagram is shown those areas covered by accurate surveys. The reconnaissance maps made by the Federal Survey years ago without co-operation are not accurate but are useful as base maps for many purposes.

During the past biennial period the Green City and the Queen City sheets of Putnam and Schuyler counties and the Mecca sheet of Platte county have been completed. In addition we have revised the culture on the Calhoun, Clinton, Richmond, Lexington, and Huntsville sheets and published a new issue of each.

Work is now in progress on the Sturgeon quadrangle comprising 225 square miles in Boone county. During the past two years the Rolla quadrangle and the Aurora quadrangle were engraved and published.

The total area mapped during the period was 687 square miles, including 271 miles of primary levels; 75 miles of primary traverse; 2,466 miles of secondary traverse. Sixty-three bench marks were established. The culture was revised on areas aggregating 1,250 square miles.

Up to the present time accurate topographic maps have been prepared covering the following quadrangles. The total area in-

cludes 7,215 square miles or slightly more than one-tenth of the State. These maps are published on the scale of one inch to the mile. The Forsythe shows differences of elevation of 50 feet on a scale of one-half inch to the mile. The Aurora and Joplin sheets show a difference in elevation of ten feet, while the remainder indicate a difference of 20 feet in elevation.

	Square miles.		Square miles.
Wyandotte	75	Higdon	240
Joplin	340	Eldon	225
Aurora	550	Weingarten	240
Forsythe	945	Gravois Mills	225
Granby	15	Calhoun	220
Macon	235	Clinton	220
Atlanta	220	Lexington	220
Rolla	245	Higginsville	220
Green City	225	Richmond	220
Queen City	225	Bevier	235
Mecca	225	Huntsville	220
Leavenworth	160	Iron Mountain	220
St. Louis	160	Mine Lamotte	220
Potosi	210		
Bonne Terre	215	Total	7,215
Farmington	240		

INFORMATION BUREAU.

Many citizens within the State do not have a knowledge of the commercial minerals or do not know what minerals may occur in the various geologic formations. The most important duty of the Survey is to give the citizen reliable data covering the possibilities of each region, and such authentic information can be obtained by anyone through the department.

Unfortunately there are many unscrupulous assayers and promoters who, for the sake of possible future fees, make misleading reports that cause a waste of both time and money.

The Bureau receives hundreds of letters requesting advice concerning every section of the State. Samples of rocks and ores are received daily. These are tested as rapidly as possible and the request answered by a reliable report. The Bureau, however, does not do commercial assaying for developed properties.

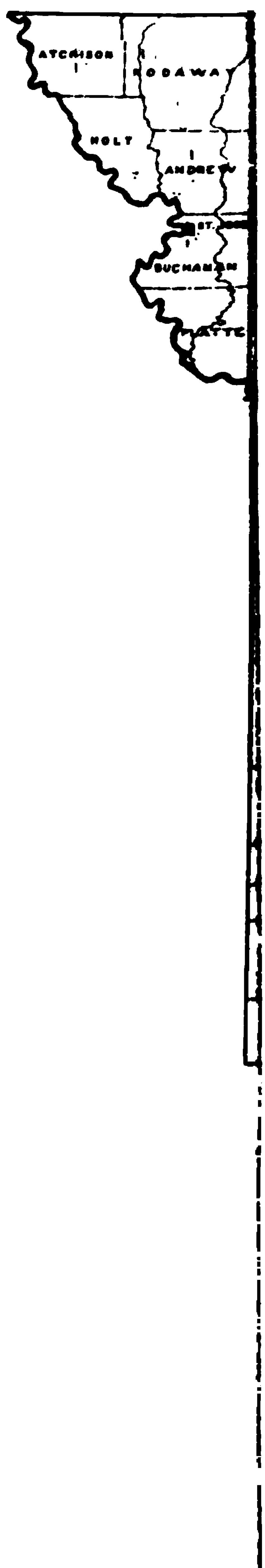
In many cases, members of the staff visit properties and outline systematic plans for prospecting. This is usually done where we do not already have the information in the office.

There is a continual demand for the reports of the Bureau.

During the past biennial period we have distributed more than 3,300 copies of the reports available for distribution. In addition, we have sent over 1,500 topographic maps, 1,000 State maps, and 2,000 biennial reports. There are almost daily requests for the earlier reports of the Bureau which are now out of print.

At the present time the following reports are available for distribution and will be forwarded to any citizen upon the receipt of transportation charges:

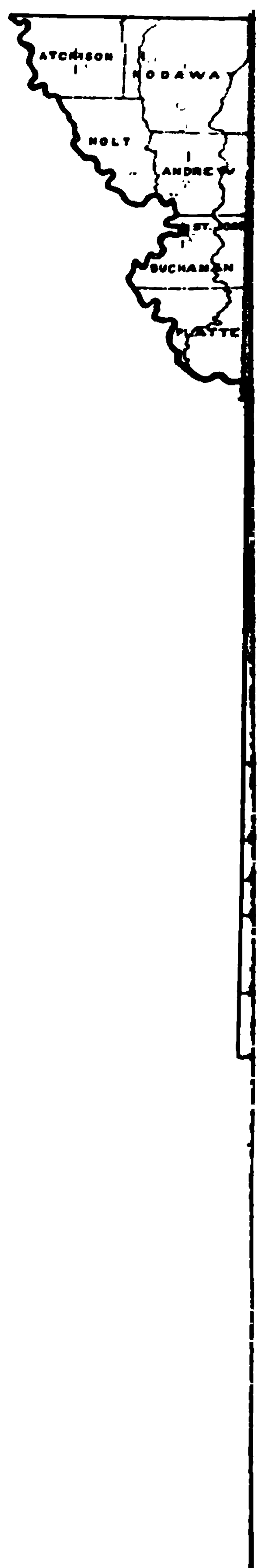
	Postage.
Preliminary report on Structural and Economic Geology, Vol. XIII, 1900, by John A. Gallaher	25c
Geology of Miller County, Vol. I, 2nd series, E. R. Buckley, A. F. Smith and S. H. Ball	15c
The Quarrying Industry of Missouri, Vol. II, 2nd series, 1904, by E. R. Buckley and H. A. Buehler	40c
Biennial Report of the State Geologist to the Forty-second General Assembly, by E. R. Buckley	10c
The Geology of Moniteau County, Vol. III, 2nd series, 1905, by F. B. VanHorn	15c
Biennial Report of the State Geologist to the Forty-third General Assembly, by E. R. Buckley	10c
Geology of the Granby Area, Vol. IV, 2nd series, 1906, by E. R. Buckley and H. A. Buehler	20c
Biennial Report of the State Geologist to the Forty-fourth General Assembly, by E. R. Buckley	10c
Public Roads, Vol. V, 2nd series, by E. R. Buckley	15c
Lime and Cement Resources of Missouri, Vol. IV, 2nd series, 1907, by H. A. Buehler	25c
Geology of Morgan County, Vol. VII, 2nd series, 1908, by C. F. Marbut	15c
Geology of Pike County, Vol. VIII, 2nd series, 1908, by R. R. Rowley	15c
The Geology of the Disseminated Lead Deposits of St Francois and Washington Counties, Vol. IX, 2nd series, 1909, by E. R. Buckley	45c
Iron Ores of Missouri, Vol. X, 2nd series, by G. W. Crane	35c
Coal Deposits of Missouri, Vol. XI, 2nd series, by Henry Hinds	35c
Geological State Map	10c


ATCHISON
HOLT
ANDREW
ST.
BUCHANAN

During the past biennial period we have distributed more than 3,300 copies of the reports available for distribution. In addition, we have sent over 1,500 topographic maps, 1,000 State maps, and 2,000 biennial reports. There are almost daily requests for the earlier reports of the Bureau which are now out of print.

At the present time the following reports are available for distribution and will be forwarded to any citizen upon the receipt of transportation charges:

	Postage.
Preliminary report on Structural and Economic Geology, Vol. XIII, 1900, by John A. Gallaher	25c
Geology of Miller County, Vol. I, 2nd series, E. R. Buckley, A. F. Smith and S. H. Ball	15c
The Quarrying Industry of Missouri, Vol. II, 2nd series, 1904, by E. R. Buckley and H. A. Buehler	40c
Biennial Report of the State Geologist to the Forty-second General Assembly, by E. R. Buckley	10c
The Geology of Moniteau County, Vol. III, 2nd series, 1905, by F. B. VanHorn	15c
Biennial Report of the State Geologist to the Forty-third General Assembly, by E. R. Buckley	10c
Geology of the Granby Area, Vol. IV, 2nd series, 1906, by E. R. Buckley and H. A. Buehler	20c
Biennial Report of the State Geologist to the Forty-fourth General Assembly, by E. R. Buckley	10c
Public Roads, Vol. V, 2nd series, by E. R. Buckley	15c
Lime and Cement Resources of Missouri, Vol. IV, 2nd series, 1907, by H. A. Buehler	25c
Geology of Morgan County, Vol. VII, 2nd series, 1908, by C. F. Marbut	15c
Geology of Pike County, Vol. VIII, 2nd series, 1908, by R. R. Rowley	15c
The Geology of the Disseminated Lead Deposits of St. Francois and Washington Counties, Vol. IX, 2nd series, 1909, by E. R. Buckley	45c
Iron Ores of Missouri, Vol. X, 2nd series, by G. W. Crane	35c
Coal Deposits of Missouri, Vol. XI, 2nd series, by Henry Hinds	35c
Geological State Map	10c


ATCHISON
HOLT
ANDREW
BUCHANAN
PLATTE


ATCHISON
NODAWA
HOLT
ANDRE
ST
BUCHAN

CHAPTER II.

FUTURE WORK OF THE BUREAU OF GEOLOGY AND MINES.

The Bureau now has available for distribution subject reports covering Building Stone, Lime and Cement, Lead and Zinc, Coal, and Iron, and areal reports covering Miller, Morgan, Moniteau, Pike, Jackson, and parts of Phelps, Washington, St. Francois, Jasper, Newton, Lawrence, and Barry counties. The demand for these reports and requests for similar reports covering additional areas and mineral resources has continued to increase with the phenomenal growth of the mineral industries.

The Survey should continue to investigate the mineral resources and issue reports as rapidly as possible. The following brief outline indicates a number of the subjects that should be given early attention.

LEAD AND ZINC.

To make a complete study of the possible lead and zinc producing area will require detailed surveys of a large part of the Ozark region, as ores of these metals are found in almost every county of south Missouri. The mining of lead and zinc is the most important mineral industry of the State. At present the Survey has available reports covering the Disseminated Lead District of Washington and St. Francois counties of southeast Missouri, and of the Granby area of Newton county in southwest Missouri. Mapping has been completed on the Aurora-Wentworth area in Lawrence and adjoining counties.

As the ores of each district occur under different geologic conditions, similar studies should be made in other districts. Important camps occur in Newton, Greene, Madison, Jasper, Franklin, Ozark, and Jefferson counties.

CLAY DEPOSITS.

Commercial deposits of clay or shale occur in practically every county, and Missouri ranks as one of the chief clay producing states in the Union. The nature and occurrence of the clays depend upon the geologic formations from which they are derived. The follow-

ing brief mention of the types which have been utilized indicates the wide distribution of the deposits.

(1) China ware clay or kaolin: A white clay found in southeast and southwest Missouri.

(2) Flint fire clay: A high grade, non-plastic clay found in the Central Ozark region.

(3) Plastic fire clay: Occurs in St. Louis county and in the Coal Measures of north and west Missouri.

(4) Loess clay: Borders the Missouri and Mississippi rivers throughout their course in Missouri.

(5) Residual clay: Suitable for common brick. Occurs throughout the southern part of the State.

(6) Pottery clay: Found in Henry county and other areas in west Missouri.

(7) Gumbo: Burned for railroad ballast, utilized chiefly in the northern part of State.

(8) Shale: Occurs in the Coal Measures and other formations in the northern and western parts of State.

(9) Terra Cotta clay: Utilized chiefly in St. Louis.

(10) Tile and Sewerpipe clays: Occurs in the northern and western parts of State.

Each of these types has distinct chemical and physical properties making them especially valuable in the manufacture of certain kinds of manufactured products.

Burning tests and chemical analyses should be made of each and a report issued showing in detail the character and distribution of each type found in the State.

UNDER GROUND WATER SUPPLY.

Information is desired in almost every county concerning the horizons at which potable waters may be obtained for drinking and other purposes. The Survey receives many requests from cities, corporations and individuals, located in all sections of the State for information concerning the depth and purity of the water-supply throughout the State.

The purity of the water will depend largely upon the geologic formation through which it passes. Missouri is underlain by a variety of formations, many of which contain water unsuitable for drinking purposes. Potable waters occur at different horizons throughout different parts of the State. Through a study of the

structural features of the State combined with a study of the records of holes already drilled the depth at which pure water may be obtained can be determined for each county. A report showing such data would be invaluable for cities or individuals desiring a pure and adequate water-supply.

COPPER ORES.

Copper is being recovered at present as a by-product in the concentration of lead ores in southeast Missouri. Small amounts of this metal occur with the disseminated ores of St. Francois, Madison, and Washington counties. Heretofore it has not been saved and millions of pounds have been lost in the tailings from the lead mills. Extensive deposits of copper have been mined east of Fredericktown in Madison county, where the ores occur near the contact of the granite and limestones.

In Ste. Genevieve county, the Cornwall Copper Mine after being idle for many years, is again in operation and it is reported that the Copper Mountain Company near Sullivan has encountered commercial ore and will soon place their smelter in blast. Some copper has also been found in conjunction with the iron ores of central Missouri. Prospecting is now being done in Shannon county at what is known as the Jerk Tail property.

At present the Bureau has no report showing the occurrence of the various types of deposits.

COBALT AND NICKEL.

Deposits of cobalt and nickel are rare, and but few states contain such ores. Missouri has extensive ore bodies near Fredericktown in Madison county, where these metals occur in conjunction with copper and lead. Up to the present time exploitation has been restricted to a comparatively small area although similar geologic conditions are found over a considerable portion of the granitic region of Madison and adjoining counties. The area should be studied carefully.

TRIPOLI.

The production of tripoli is one of the unique mineral industries of the State. In the vicinity of Seneca a number of quarries have been opened in beds of decomposed flint, the material being utilized as a polishing powder and for filtering purposes. In Perry and adjoining counties bordering the Mississippi river similar

material is found in small pieces mixed with residual clay. As yet no study has been made of the extent and nature of the deposits in either area.

GLASS SAND.

The manufacture of high grade plate glass requires a white sand free from impurities, and the extensive glass industries of Valley Park and Crystal City are dependent upon deposits of such sand in Franklin and Jefferson counties. The St. Peters sandstone from which this sand is obtained occupies a belt extending from Cape Girardeau on the south to Calloway county on the north, with additional areas in Pike and Lincoln counties.

Throughout this extended belt, quarrying is restricted to the area about Crystal City and Pacific. In order to indicate the thickness and general character of this sandstone, as well as show the exact location of this formation the Bureau has started to map the entire area. The investigation will include field work in approximately 11 counties.

MINERAL PAINTS.

One of the extensive mineral industries of the State is the manufacture of mineral paint, the output in 1911 being valued at more than $2,000,000.

The raw materials include a variety of substances, embracing ocherous iron ores, white limestone, lead and zinc ores, ferruginous clays and barytes. The occurrence and extent of these deposits and the uses of the pigments should be shown in a detailed report.

AREAL REPORTS.

The volumes of the Bureau available for distribution include reports covering Pike, Miller, Morgan, and Moniteau counties and parts of Jasper, Newton, Lawrence, Barry, Ste. Genevieve, Washington, and St. Francois counties, while reports are completed and in process of publication covering Jackson, and parts of Phelps counties. Mapping is completed and reports being prepared on parts of Platte, Schuyler, and Putnam counties. Earlier volumes include detailed reports on parts of Iron, Madison, Lafayette, Ray, Randolph, Macon, Greene, Boone, and Henry counties. These volumes, however, are now out of print.

There are fifty counties in the State having no detailed or

reconnaissance reports. These areas should be surveyed as soon as possible.

REPORT ON MINERAL RESOURCES.

The Bureau has general information covering the production and value of the various mineral resources. In order that the phenomenal growth and stability of these industries may be shown a general volume treating of all the mineral industries should be published. Such a report can be prepared with about one season's field work.

TOPOGRAPHIC MAPPING.

The topographic branch of the Survey work deals primarily with the making of an accurate base map of the State. The work is done by quadrangle or special areas and up to the present time each area mapped has been located in some important mining region or center of population.

The importance of an accurate topographic map cannot be overestimated. They are utilized by almost every department of the Government, as well as by mining and manufacturing companies and individuals. They are indispensable for accurate geologic work.

The maps now being prepared in Missouri are on a scale of one mile to the inch and show differences in surface elevation of 20 feet. The results are plotted from actual field surveys superimposed upon the Government land plats. By this method a very accurate map is obtained, in fact far superior to those usually published by private parties. As shown by the accompanying map approximately 7,250 square miles have been surveyed.

This work is being done in co-operation with the United States Geological Survey. Under the terms of this agreement the Federal Survey pays one-half of all field expenses and engraves the plates without expense to the State.

If the work were done without co-operation it would cost the State more than twice as much.

During the past biennial period Missouri devoted $5,000 per year to this work, a like amount being appropriated by the Federal Government. During the same period the United States Survey was willing to spend a total of $30,000 in Missouri on this work. Twenty thousand dollars of this amount was not obtained because of lack of appropriation on the part of the State.

The Government will agree to meet an appropriation of $30,000 during the coming biennial period. In order to take advantage of this offer the State should make a like appropriation.

APPROPRIATIONS.

The above brief outline indicates a number of the problems confronting the Bureau and the urgent need of extending the work. No other branch of industry in the State has expanded with such rapidity as mining and in order to be of the greatest service the appropriations accorded the Bureau should be commensurate with the increase of the industry.

We therefore, earnestly recommend that the following appropriation be made for the work of this Bureau during the next biennial period.

Support	$50,000.00
Publications	7,500.00
Topography	30,000.00
Total	$87,500.00

CHAPTER III.

A NEW MINERAL PAINT.

The red and yellow oxides of iron and ferruginous clays of proper physical properties are extensively utilized in the manufacture of natural mineral paints such as ocher, umber, sienna, and venetian red. The iron deposits throughout the Central Ozark region have produced a large tonnage of raw material for paints of this character.

Recently specular iron ore has been mined and utilized in the manufacture of a noncorrosive paint sold under the trade name of "Formastat".

The following is a brief description of the deposit which probably has the distinction of being the only one of its kind being utilized in the United States. Because of the greasy feel to the mineral the property is known as the "Greasy Mine".

THE GREASY MINE.

Owned by Deacon and Lambert, St. Louis, Missouri.

This mine is located in St. Francois county, about six miles south of Doe Run, in the N. E. ¼, S. E. ¼, Sec. 8, T. 34 N., R. 5. E. It is situated in a small ravine tributary to Wachita creek at the foot of the northeast slope of Bald Mountain.

The country rock in the vicinity of the mine consists chiefly of granite with some porphyry capping the higher hills like Bald Mountain. The Lamotte sandstone occurs in the valleys of the larger streams. The granite which forms all of the outcrops within a quarter of a mile of the mine is light pink in color and varies from holo-crystalline to porphyritic in texture. Its principal constituents are feldspar and quartz with some biotite and occasional crystals of apatite, zircon, and magnetite. At Bald Mountain it grades upward into a quartz porphyry. The Lamotte sandstone which lies unconformably upon the granite is usually light yellow to brown in color and rather coarse-grained, particularly at the contact with the granite where it becomes conglomeratic. The surface and soil, which are light colored and sandy, have resulted chiefly from

the decomposition of the granite. None of the rocks show metamorphism other than weathering, the only secondary structure being numerous small fissures due probably to consilidation.

The ore outcrops at one point on the west bank of a small ravine. It occurs in the form of several small fissure veins in the granite which also carries some disseminated ore. The ore bearing veins are nearly vertical and have a strike of about north 25 degrees east.

Developments consist of a shaft 100 feet deep, from the 50-foot level of which drifts have been driven along the strike of the vein for a distance of 48 feet in a northeasterly direction and 70 feet in a southwesterly direction. The 48-foot drift encountered good vein ore throughout its length. The veins in this drift vary from a fraction to six inches in width and are often several in number, distributed over a zone two to five feet wide. At a point 30 feet from the shaft a cross drift has been driven 24 feet in a northwesterly direction. The first 18 feet of this drift is in granite carrying 10 to 15 per cent of disseminated ore. This ore is cut out abruptly by a two to three-foot seam of soft gray talcose material carrying disseminated ore and seams of hard massive hemitite. Beyond this is hard pink granite, barren of ore except for thin seams of hemitite cementing joints.

The 70-foot drift which extends southwest from the shaft is in vein and disseminated ore except for six to ten feet of barren granite near its south end through which it passed in good ore. From the middle of this drift a cross drift has been driven 20 feet to the southeast disclosing disseminated ore throughout its length.

The vein ore has been followed to a depth of 100 feet in the shaft and at that depth is enclosed by disseminated ore of the same grade and character as that showing in the cross drifts at the 50-foot level.

From the developments it would appear that there is here a zone of vein ore two to five feet in width and at least 100 feet deep and 130 feet in length which is bordered on either side by parallel zones of disseminated ore at least 20 feet wide.

The ore is a highly micaceous hematite, resembling graphite in appearance and is soft and greasy to the feel. Near the end of the northwest cross drift it is in part hard and massive and unfit for pigment purposes. The vein ore carries occasional stringers

of milky quartz and is mixed with more or less talcose material. The disseminated ore carries numerous small individual crystals of pyrite and locally small quantities of chalcopyrite. Pyrite also occurs in the vein ore, particularly where the latter is massive.

The best grade of ore is that in the small veins which run 50 to 80 per cent hematite. The disseminated ore ranges up to 20 per cent hematite, much of the ground assaying 15 per cent.

The deposit probably belongs to the pegmatitic class of vein filling and impregnation by replacement due to deep seated hot solutions.

The deposit is being exploited as a source of mineral paint and a mill is about to be constructed to separate the ore and rock. Experiments in milling have produced a product running 92.7 per cent hematite and it is thought that this can be improved upon. The milled product is used as a pigment under the trade mark "Formastat" and sells for from 90 to 130 dollars per ton. It is recommended as a coating for steel structures particularly those exposed to acid, damp, and corroding influences. By special processes it is given a gold, silver gray, or copper color, such treatment increases the cost of the product.

CHAPTER IV.

ANSWERS TO PETITIONS.

PETITION OF SIMEON BRINK ET AL., SPRINGFIELD, MISSOURI.

In compliance with your petition, the following described lands were examined on April 14 and 15, 1912, to wit:—the N. W. 1/4 of the N. E. 1/4 and the S. E. 1/4 of Sec. 21, T. 24 N., R. 22 W.; the S. E. 1/4 of the N. E. 1/4 of Sec. 28, T. 24 N., R. 22 W.; and the S. W. 1/4 of Sec. 27, T. 24 N., R. 22 W.

The general topography of the country is very rough, the area being characterized by narrow ridges and deep V-shaped ravines. The crests of the ridges lie approximately 300 feet above stream level.

Rocks of two geologic periods outcrop in the district. The lower formation, consisting of cotton rock and cherty dolomite, is known as the Jefferson City and belongs to the Cambrian succession (formerly called Silurian). The Burlington member of the Mississippian series comprises the upper formation and consists of cherty limestone. The contact between the Jefferson City and Burlington formations occurs at an elevation of about 180 feet above the valleys.

N. W. 1/4, N. E. 1/4 of Sec. 21.—This forty is traversed from east to west by a deep ravine. Near the west line two small cuts have been driven into the south bank of the stream, exposing a maximum thickness of twelve feet of Jefferson City dolomite. The walls of the cuts show several thin seams of quartz and partly oxidized pyrites of iron occurring along bedding planes and joints. These seams vary from one-fourth inch to two inches in thickness and occasionally enclose a small lense of sphalerite ("jack") and galena ("lead"). Near the surface of the cut occurred a few boulders of cellular quartz which contained specks of malachite (green carbonate of copper). The copper carbonate is not present in sufficient quantity to constitute an ore of copper. The dolomite exposed in the cuts is very dense, there being no cavities such as

might result from the leaching action of water and which would present favorable conditions for the deposition of mineral.

The adjoining hill-slopes expose a nearly continuous section of Cambrian dolomite and Burlington limestone. At numerous places on these slopes, lenses of calcite and galena are exposed in the ledges, representing points of local mineral concentration. The ledges exposed lie horizontal and show no faulting or folding.

S. E. ¼, N. E. ¼ of Sec. 28.—Near the head of a ravine on this forty occurs what is locally known as the "Old Spanish Mines". Here two openings occur in the ledges near the Burlington-Cambrian contact. It is reported that these openings have been followed for a considerable distance below, and backward from the surface. They are apparently the surface exposure of a more or less extensive cavern or cave system which has resulted from the action of underground water. Some lead is reported to have been found in the clays near the openings.

S. W. ¼, S. W. ¼ of Sec. 27.—On the east slope of a high ridge in this forty is exposed a three-foot ledge of porous dolomite which has been found to carry varying amounts of calcite and galena. The porous nature of this ledge is due to water leaching and the resulting cavities are of various size and shape. Should the cavities be found to be quite generally filled with lead or zinc this bed should prove of economic importance.

At a number of places in Secs. 21, 27 and 28, lenses of galena occur in ledges exposed on the steep hill-slopes. No faulting or folding, whose accompanying structures would offer favorable conditions for the concentration of an ore deposit of workable size, was observed in the district. The ledges described in the S. W. ¼, S. W. ¼ of Sec. 27, offers the most favorable point to prospect and can be best exploited by drifting into the hillside.

Very respectfully submitted,

V. H. HUGHES,
Assistant State Geologist.

PETITION OF C. B. KELLER ET AL., TIPTON, MISSOURI.

In compliance with your request I examined the cave owned by the Onyx Quarries Company, on May 19, 1912. The cave is located five and one-half miles southwest of Linn Creek and one-half

mile east of Arnholdt's Mill; it opens on the east bank of the Niangua river at the base of a high, narrow ridge. The entrance, which is ten feet above the level of the river, consists of a winding passage approximately seven feet high, eight feet wide, and sixty feet long. The general trend of the cave is in a southeasterly direction.

The first onyx of importance occurs at a distance of five hundred feet from the mouth of the cave. At this point three stalagmites occur, two of which have a diameter of approximately six feet at the base and are seven feet high; the third has a diameter of approximately four feet at the base and is twelve feet in height. Three stalactites occur directly above the stalagmites. While they could not be measured they have approximately the same dimensions as the stalagmites. The onyx is white, hard, and more or less banded.

At approximately seven hundred feet from the mouth of the cave there occurs a large pillar of onyx forty-five feet in diameter and fully forty feet in height. The pillar joins the wall of the cave on one side and may consist in part of dolomitic limestone which constitutes the walls of the openings. It rests upon horizontally banded travertine which forms a platform from three to four feet in height, this travertine is brittle and porous.

From an examination of the surface of the large pillar it apparently consists of a white, hard variety of calcareous onyx which is apparently quite free from openings or pores. No work has been done upon this pillar and the general nature and porosity of the onyx occurring within the mass cannot be determined without some development work; it is very possible that the interior of the pillar will show considerable banding. About one hundred feet to the south the floor of the cave rises to within a few feet of the roof. Here the roof and floor are covered with stalactites and stalagmites which rarely exceed two feet in diameter and three feet in length. The onyx is apparently of the same quality as that noted in the larger pillar to the north.

The floor of the cave between the above points consists chiefly of clay and brown travertine, the latter which is present in a considerable quantity is too soft for commercial purposes.

Only the larger stalactites and large pillars are suitable for sawing into slabs of commercial dimensions. A large number of the stalagmites are too small to be utilized in this manner.

The smaller blocks and chips obtained from the quarry can, however, be used in conjunction with Portland and other cements for the production of artificial stone having the appearance of a breccia. Much of the waste obtained from eastern and foreign marbles is utilized in this manner. The small particles of onyx will take a good polish under such conditions.

In order to demonstrate the commercial possibility of this property some development work should be done.

The Niangua and Osage rivers may be used to transport the onyx to Bagnell, the nearest railroad station.

Respectfully submitted,

V. H. HUGHES,
Assistant State Geologist.

CHAPTER V.

CHEMICAL ANALYSES.

During the past biennial period the Bureau has tested hundreds of specimens to determine their commercial value and in many cases this work has called for complete chemical analyses.

The following include a number of the more important analyses made on ores, rocks, clays, and mineral water either collected by members of the Survey staff or forwarded by citizens throughout the State. The analyses were made by Mr. A. X. Illinski, Chemist to the Survey.

WATER—MAITLAND.

Sample of water was obtained from a flowing well located on the farm of H. L. Leeper, three-quarters of a mile east of Maitland, Holt county. The well has a total depth of 374 feet, there being only a slight flow. The water is used locally for medicinal purposes. The sample analyzed as follows:

Silica	(SiO_2)	0.4205 grains per gallon
Iron oxide	(Fe_2O_3)	0.0442 grains per gallon
Alumina	(Al_2O_3)	0.0992 grains per gallon
Sodium sulphate	(Na_2SO_4)	46.0100 grains per gallon
Sodium chloride	($NaCl$)	494.2000 grains per gallon
Potassium chloride	(KCl)	131.4000 grains per gallon
Magnesium chloride	($MgCl_2$)	17.2200 grains per gallon
Calcium chloride	($CaCl_2$)	13.8300 grains per gallon
Calcium carbonate	($CaCO_3$)	2.5840 grains per gallon
Lithium	(Li_2O)	Present.
Total		705.8279 grains per gallon
Total solids		706.5 grains per gallon
Chlorine		384.0 grains per gallon
Sulphur		10.34 grains per gallon
Specific gravity at 63° F		1.0126

WATER—CARROLLTON.

Sample of water submitted by Mr. Jas. M. Wilcoxon, taken from the deep well drilled by the city, analyzed as follows:

Silica	(SiO_2)	0.62	grains per gallon
Iron-aluminum oxides	($(Fe:Al)_2O_3$)	0.04	grains per gallon
Calcium carbonate	($CaCO_3$)	14.99	grains per gallon
Calcium chloride	($CaCl_2$)	19.53	grains per gallon
Magnesium chloride	($MgCl_2$)	43.15	grains per gallon
Sodium sulphate	(Na_2SO_4)	60.39	grains per gallon
Sodium chloride	($NaCl$)	447.30	grains per gallon
Potassium chloride	(KCl)	124.60	grains per gallon
Total		710.62	grains per gallon
Specific gravity at 55° F		1.014	

WATER—PIERCE CITY.

Sample of water from W. G. Means' farm, near Pierce City, was analyzed as follows:

Silica	(SiO_2)	0.496	grains per gallon
Iron-aluminum oxides	($(Fe:Al)_2O_3$)	0.216	grains per gallon
Calcium carbonate	($CaCO_3$)	15.450	grains per gallon
Magnesium carbonate	($MgCO_3$)	4.670	grains per gallon
Potassium chloride	(KCl)	1.640	grains per gallon
Sodium chloride	($NaCl$)	0.566	grains per gallon
Sodium sulphate	(Na_2SO_4)	2.220	grains per gallon
Sodium carbonate	(Na_2CO_3)	0.409	grains per gallon
Total		25.667	
Specific gravity at 67.7° F		1.0047	

WATER—MINEOLA.

Sample of mineral water obtained from spring near Mineola. This water is charged chiefly with chlorides and a small amount of sulphate.

Silica	(SiO_2)	0.572	grains per gallon
Iron-aluminum oxides	($(Fe:Al)_2O_3$)	0.123	grains per gallon
Sodium sulphate	(Na_2SO_4)	15.190	grains per gallon
Sodium chloride	($NaCl$)	198.500	grains per gallon
Potassium chloride	(KCl)	48.370	grains per gallon
Magnesium chloride	($MgCl_2$)	12.340	grains per gallon
Calcium chloride	($CaCl_2$)	17.990	grains per gallon
Calcium carbonate	($CaCO_3$)	12.050	grains per gallon
Total		305.130	grains per gallon
Specific gravity at 59° F		1.0088	
Chlorine		164.1	grains per gallon
Sulphur trioxide		8.569	grains per gallon
Sulphur		3.431	grains per gallon

WATER—JEFFERSON CITY.

Sample of water obtained from five miles southwest of Jefferson City. This water carries sulphates and a very small amount of chlorides.

Sodium chloride	($NaCl$)	2.599 grains per gallon
Sodium sulphate	(Na_2SO_4)	25.660 grains per gallon
Potassium sulphate	(K_2SO_4)	11.040 grains per gallon
Calcium carbonate	($CaCO_3$)	14.430 grains per gallon
Magnesium carbonate	($MgCO_3$)	21.900 grains per gallon
Silica	(SiO_2)	1.145 grains per gallon
Iron carbonate	($FeCO_3$)	0.278 grains per gallon
Total		77.052 grains per gallon
Specific gravity at 66.7° F		1.0052

WATER—NEWBURG.

The following analysis shows the composition of the water obtained from an artesian well drilled on the J. Pullen farm south of Newburg, Phelps county:

Potassium chloride	(KCl)	0.1227 grains per gallon
Potassium sulphate	(K_2SO_4)	0.1577 grains per gallon
Sodium sulphate	(Na_2SO_4)	1.022 grains per gallon
Sodium carbonate	(Na_2CO_3)	0.2745 grains per gallon
Calcium carbonate	($CaCO_3$)	8.299 grains per gallon
Magnesium carbonate	($MgCO_3$)	6.997 grains per gallon
Iron carbonate	($FeCO_3$)	0.111 grains per gallon
Silica	(SiO_2)	0.4438 grains per gallon
Total		17.4287 grains per gallon
Specific gravity at 74° F		1.0022

CLAY—FULTON.

The following samples were taken from the clay pit of the Fulton Fire Clay Company at Fulton, and represent (1) clay from which highest grade fire brick are being made; (2) standard clay as taken from pit, used in the manufacture of Fulton extra brick; and (3) clay obtained from beneath coal. This clay is not utilized at present.

		(1)	(2)	(3)
Water (at 105°)	(H_2O)	1.41%	1.51%	2.01%
Water (blst.)	(H_2O)	11.96%	12.12%	11.26%
Silica	(SiO_2)	45.85%	45.34%	47.02%
Iron oxide	(Fe_2O_3)	3.33%	3.39%	3.17%
Alumina	(Al_2O_3)	36.27%	35.96%	35.67%
Calcium oxide	(CaO)	Trace.	Trace.	Trace.
Magnesium oxide	(MgO)	0.45%	0.52%	0.51%
Sodium oxide	(Na_2O)	None.	Trace.	Trace.
Potassium oxide	(K_2O)	0.27%	0.85%	0.52%
Totals		99.54%	99.69%	100.16%

CLAY—KANSAS CITY.

The following is an analysis of a clay submitted by Mr. F. D. Randall of Kansas City:

Silica	(SiO_2)	47.29%
Alumina	(Al_2O_3)	37.20%
Iron oxide	(Fe_2O_3)	4.51%
Calcium oxide	(CaO)	None.
Magnesium oxide	(MgO)	0.59%
Total		89.59%

CLAY—NEVADA.

The following clay was obtained from J. Sam Brown of Nevada, Mo. The clay is comparatively high in alumina and low in fluxes.

Water (105°)	(H_2O)	1.85%
Water (blst.)	(H_2O)	8.47%
Silica	(SiO_2)	51.62%
Iron oxide	(Fe_2O_3)	3.88%
Alumina	(Al_2O_3)	30.50%
Calcium oxide	(CaO)	0.11%
Magnesium oxide	(MgO)	1.27%
Total		98.70%

COAL—KIRKSVILLE.

The following analysis was made of a sample of coal taken from the mine of the Star Coal Company at Kirksville, Mo.

Water (105°)	5.31%
Volatile hydrocarbons	40.19%
Fixed carbon	43.31%
Ash	11.19%
Total	100.00%
Sulphur	5.37%
B. T. U	12,828

COAL—PRINCETON.

Diamond drill holes in the vicinity of Princeton encountered coal at a considerable depth. The following analyses are of samples taken from two of the seams of commercial thickness. The veins sampled occur at approximately the same horizon as the bed mined at Cainesville, Mo.

	(1)	(2)
Moisture	3.96%	2.08%
Volatile hydrocarbons	37.81%	38.91%
Fixed carbon	49.75%	37.06%
Ash	8.48%	21.95%
Totals	100.00%	100.00%
Sulphur	4.89%	6.92%

COAL—KNOBNOSTER.

John Burns of Knobnoster, Mo., submitted a sample of coal for analysis. The sample runs very high in ash as shown by the following results:

Moisture (105°)	2.30%
Volatile hydrocarbons	40.02%
Fixed carbon	39.63%
Ash	18.05%
Total	100.00%
Sulphur	5.66%

MANGANESE ORE—ELLSINORE.

A sample of manganese ore was submitted for determination by Mr. J. P. Thomas of Ellsinore, Mo., which ran 21.52% manganese.

MANGANESE ORE—ALTON.

Mr. S. C. Pullum of Alton, Mo., submitted a sample of ore which ran 26.18% manganese. The ore is said to be found in considerable quantity three miles west of Alton.

IRON ORE.

The following are analyses of three specimens of iron ore having much the same composition. Nos. 1 and 2 are from Section 8, Township 42 N., Range 3 W., and No. 3 is from Section 4, Township 45 N., Range 10 W.

		(1)	(2)	(3)
Moisture (105°)	($H_2O°$)	0.199%	0.68%	0.825%
Moisture (blst.)	($H_2O°$)	2.225%	3.22%	4.459%
Silica	(SiO_2)	8.200%	6.26%	13.650%
Iron	(Fe)	56.930%	58.69%	48.830%
Sulphur	(S)	0.082%	0.14%	Trace.
Phosphorus	(P)	0.241%	0.09%	Trace.

LIMESTONE—CARTHAGE.

The following analyses were made from samples of limestone collected from the fresh face of the quarry of the Carthage Marble Quarry Company. Each analysis indicates the composition of one of the important ledges in the quarry.

	(1)	(2)	(3)	(4)	(5)
Insoluble	0.44%	0.20%	0.38%	0.36%	0.40%
Iron and aluminum oxides. (Fe_2O_3:Al_2O_3)	0.60%	0.70%	0.58%	0.50%	0.80%
Calcium carbonate ($CaCO_3$)	98.68	98.63	99.17	99.06	98.63
Magnesium carbonate ($MgCO_3$)	0.67	0.85	0.50	0.53	0.60
	100.39%	100.38%	100.63%	100.45%	100.43%

LIMESTONE.

Mr. Daniel Spoonhour of Mulberry, Kansas, submitted a dark red limestone for analysis. The ledge occurs in Stone county, Mo. The sample gave the following results:

Calcium carbonate	($CaCO_3$)	96.01%
Magnesium carbonate	($MgCO_3$)	0.40
Iron and alumina	(Fe_2O_3:Al_2O_3)	1.38
Moisture	(H_2O)	0.18
Insoluble		2.17
		100.14%

LIMESTONE—STE. GENEVIEVE.

The following is an analysis of a sample of limestone received from Mr. August J. Brisner of Ste. Genevieve, Mo. The sample has much the appearance of Burlington limestone.

Moisture	(H_2O)	0.72%
Silica	(SiO_2)	0.54
Iron and alumina	(Fe_2O_3:Al_2O_3)	0.13
Calsium carbonate	($CaCO_3$)	97.80
Magnesium carbonate	($MgCO_3$)	0.59
		99.78%

The above limestone sample came from a ledge in the quarry operated by the Ste. Genevieve Lime and Marble Company.

LIME—HANNIBAL.

An analysis of the hydrated lime manufactured at Hannibal gave the following results:

Moisture .... (H_2O)	24.16%
Silica .... (SiO_2)	0.14
Iron and alumina .... (Fe_2O_3:Al_2O_3)	0.70
Calcium oxide .... (CaO)	73.07
Magnesium oxide .... (MgO)	0.21
	99.94%

CHAPTER VI.

THE MINERAL RESOURCES OF MISSOURI.

PRODUCTION FOR 1910 AND 1911.

During 1910 and 1911 the value and output of the mineral industries of the State exceeded the totals for any previous period and, although complete figures are not at present available, the production during the year passed (1912) will show a material increase over 1911. The phenomenal expansion of the mining, quarrying, and clay working industries during the past thirteen years is shown by the value of the total output, which, according to the most accurate statistics available, amounted to $13,323,245 in 1898, while in 1911 the total was $45,400,372. Few, if any, states in the Union have had a greater increase during the same period.

The following table shows the total value of each commodity produced during 1910-1911:

TABLE SHOWING TOTAL VALUES OF THE MINERAL RESOURCES OF MISSOURI IN 1910–11.

Commodity	1910	1911
Lead	$11,286,750	$12,460,902
Zinc	9,903,942	9,157,979
Coal	5,814,381	6,918,578
*Clay Products	7,058,705	6,269,145
Cement	3,858,088	3,349,312
Limestone	2,360,604	2,179,767
Mineral Paints	1,808,872	2,034,339
Sand and gravel	1,343,679	1,042,674
Lime	846,143	788,898
Clay	509,433	512,088
Iron ore	168,697	153,676
Granite	120,663	139,070
Mineral waters	96,488	86,747
Barytes	85,624	82,768
Copper	11,955	80,051
Tripoli	71,978	72,701
Silver	17,872	26,430
Sandstone	39,398	19,748
Natural gas	12,611	10,496
Pottery	29,061	5,208
**Miscellaneous	2,500	9,795
Totals	$ 45,447,444	$45,400,372

* Not including pottery.
** Including petroleum and pyrite.

These statistics have been collected through co-operation with the United States Geological Survey, excepting in the case of coal, lead, and zinc which were compiled by the Federal Bureau.

According to the above statement lead is the most important mining industry, zinc is second, while the mining of coal and the utilization of clay are of about equal importance. Missouri leads all other states in the production of lead, zinc, barytes, and tripoli.

The following pages indicate briefly the output and present condition of the various mineral industries.

ASPHALTIC ROCK.

There has been no material development of the deposits of bituminous sandstone occurring in southwest Missouri. At Liberal it has been quarried and used locally for flagging and curbing. Samples of the deposits assayed by this Bureau show a content of asphalt running as high as 15 per cent. While present commercial conditions would not warrant the treatment of this stone for the recovery of its bituminous content, it might be utilized in road construction.

BARYTES.

During the year 1911 the production of barytes was 21,550 short tons, valued at $82,768. This represents a decrease of 3,881 in tonnage and $2,856 in value as compared to 1910. The tonnage and value, by counties, is shown in the following table. The totals for St. Francois county includes one producer reporting from Jefferson county.

County	1910		1911	
	Tons	Value	Tons	Value
Cole	2,576	$7,758	2,581	$10,324
Franklin	400	1,360	405	1,362
Miller	1,356	4,107	1,922	7,270
Morgan	1,426	3,884		
St. Francois	623	1,940	823	2,400
Washington	19,050	66,575	15,819	61,412
Totals	25,431	$85,624	21,550	$82,768

Washington county produces approximately three-fourths of the output for the State and over 41 per cent of the output for the United States, which was 38,445 tons in 1911. A large part

of the crude barytes is refined in mills located at Mineral Point and St. Louis.

Barytes is found chiefly in the clays overlying the Potosi and younger Cambrian formations. In Franklin county it is obtained from fissure deposits in the limestone. In these deposits it is associated with lead ore and the barytes is a by-product obtained in cleaning the dirt as hoisted from the mine.

BUILDING STONE.

The following table shows the total value of the output of building stone during 1910 and 1911.

	1910	1911
Limestone	$2,360,604	$2,179,767
Granite	120,663	139,070
Sandstone	39,389	19,748
Total	$2,520,656	$2,338,585

There was a total decrease in value of $182,071 in 1911. The granite quarries increased their output over 14 per cent, while there was a notable decrease in the output of sandstone.

LIMESTONE.

The production of limestone for 1910 and 1911, by counties and the uses for which it was quarried, is shown in the following tables:

TOTAL OUTPUT OF LIMESTONE BY COUNTIES.

County	1910	1911
Andrew	80,669	69,544
Boone	31,165	13,462
Buchanan	22,105	23,400
Cape Girardeau	30,006	83,462
Cass	a	11,065
Clark	321	a
Cole	21,553	10,854
Daviess	31,985	21,853
Greene	123,713	113,025
Jackson	482,267	467,152
Jasper	382,755	324,788
Lafayette	19,448	3,026
Marion	32,871	70,198
Monroe	955	1,028
Montgomery	6,787	2,058
Osage	2,158	1,486
Pike	53,817	37,125
St. Francois	28,876	....

County.	1910	1911
St. Louis	810,022	755,342
Sullivan	a	1,600
*Other counties	199,131	169,299
Totals	2,360,604	2,179,767

a Included in "Other counties".
* Includes Atchison, Audrain, Bates, Bollinger, Caldwell, Clay, Clinton, Cooper, Dallas DeKalb, Franklin, Grundy, Harrison, Holt, Jefferson, Lawrence, Lewis, Lincoln, Livingston, Madison, Perry, Pettis, Platte, St. Charles, Ste. Genevieve, Saline, Scott, and Shelby counties.

TOTAL OUTPUT ACCORDING TO USES.

	1910	1911
Building purposes (rough)	$129,837	$132,011
Building purposes (sawed or cut)	443,524	380,282
Paving	10,700	70,074
Curbing	5,873	3,388
Flagging	8,244	4,559
Rubble	271,599	247,263
Riprap	194,504	247,210
Crushed, road-making	509,559	399,869
Crushed, railroad ballast	204,988	176,101
Crushed, concrete	479,394	435,679
Blast Furnace flux	51,775	24,593
Sugar factories	8,822	11,861
Agricultural purposes	892	2,669
Miscellaneous	19,441	25,336
Glass factories	21,452	18,872
Totals	$2,360,604	$2,179,767

During the past few years the use of stone in the making of concrete has greatly increased the output of crushed rock and the chief centers of limestone production St. Louis and Kansas City utilize the greater part of the output in that form. The Carthage and Phenix quarries located in Jasper and Greene counties are the chief producers of dressed building stone. These quarries utilize the Burlington limestone which outcrops over an extensive area in southwest Missouri.

GRANITE.

The production of granite is at present restricted largely to Graniteville and Syenite in Iron and St. Francois counties. The area underlain by igneous rocks occupies several counties in southeast Missouri although but little development has ever been made other than in the above localities. The output has gradually increased since the erection of the Missouri Red Granite Monument

Co's. plant in St. Louis. This firm makes a specialty of polishing the Missouri granite for structural and monumental purposes.

SANDSTONE.

The following table indicates the output and value of the sandstone quarried for various uses in 1910 and 1911:

PRODUCTION OF SANDSTONE

	1910	1911
Rough for building	5,123	2,800
Cut or sawed for building	5,830	9,804
Rubble	2,863	1,792
Riprap	21,355	4,010
Miscellaneous	4,227	1,342
Totals	39,398	19,748

The largest sandstone quarries are located north of Warrensburg in Johnson county, and at Miama in Carroll county. The industry has declined notably during recent years.

CEMENT (PORTLAND).

The production of Portland cement in 1911 was 4,114,859 bbls., valued at $3,349,312. In 1910 the output was 4,355,589 bbls., valued at $3,858,088. The decrease in output in 1911 was due primarily to general business conditions since the daily capacity of the plants was not diminished.

At the present time four plants are being operated in the State, located respectively as follows: Atlas Portland Cement Company, Ilasco, Ralls county; Kansas City Portland Cement Company, Cement City, Jackson county; St. Louis Portland Cement Company and the Continental Portland Cement Company, St. Louis, St. Louis county. The plant of the Cape Girardeau Portland Cement Company at Cape Girardeau is not in operation at the present time.

CHATS.

Mine tailings derived from the mining of lead and zinc ores in both southeast and southwest Missouri are used extensively in this State for road construction, concrete, and railroad ballast.

The following table shows the tonnage obtained from both southwest and southeast Missouri for the years 1909, 1910, and 1911.

	1909	1910	1911
Railroad purposes	355,901	1,009,533	865,011
Commercial purposes	472,934	610,789	638,592
Totals	828,835	1,620,322	1,503,603

CLAY AND CLAY PRODUCTS.

The total output of the clay industries during 1910 was valued at $7,597,199; in 1911, the production amounted to $6,786,441.

Missouri ranks 7th among the states in the value of brick and tile products, and in the manufacture of fire brick Pennsylvania alone has a greater output.

The following table shows the value of the output, exclusive of pottery, of the various brick and tile industries for 1910 and 1911.

PRODUCTION OF BRICK AND TILE FOR 1910 AND 1911.

	1910	1911
Common brick	$1,284,997	$1,309,164
Front brick	516,505	330,332
Vitrified paving brick	647,441	488,299
Ornamental brick	23,673	24,269
Drain tile	121,068	164,393
Sewer pipe	1,210,348	1,156,626
Fireproofing	146,931	123,499
Firebrick	2,059,845	1,763,548
**Miscellaneous	1,047,897	909,015
Totals	$7,058,705	$6,269,145

** Including silica, brick, enameled brick, terra cotta, stove lining, chimney tops, etc.

As shown by the above table the manufacture of fire brick and fire proofing material lead all other branches of the clay industries, being almost twice that of common brick and sewer pipe.

Many of the flint fire clay deposits are located a considerable distance from manufacturing plants and the clay is mined by local parties and shipped to St. Louis and other manufacturing centers. The clay mined and shipped was valued at $512,088 in 1910, while in 1911 the production was slightly less, being valued at $509,433. This value includes a small amount of kaolin produced in southeast Missouri. These deposits have not been worked extensively for a number of years. The kaolin carries considerable sand but with proper treatment a very white homogeneous clay is obtained.

There has been a general decline in the pottery industry during

the past few years; the value of the output for 1910 and 1911 being $29,061 and $5,208 respectively. Only comparatively low grade ware is manufactured, the output being chiefly flowerpots, yellow stoneware and red earthenware.

COAL.

The production of coal showed a notable gain in 1911 over 1910 and, with the exception of 1907, was the largest output during recent years.

The following table shows the output and value of coal during 1910 and 1911 by counties:

	1910		1911	
County	Quantity	Value	Quantity	Value
Adair	408,007	$675,979	348,559	$546,876
Audrain	40,662	85,014	29,673	69,372
Barton	222,595	350,501	295,236	425,029
Bates	95,451	168,802	88,620	152,347
Boone	19,885	41,001	22,031	46,093
Callaway	28,954	65,730	36,411	86,309
Henry	145,644	252,958	240,571	422,773
Lafayette	553,832	1,100,635	765,879	1,391,279
Linn	89,311	197,874	123,169	281,581
Macon	613,949	911,625	675,933	1,009,953
Putnam	61,968	123,424	30,276	54,279
Ralls	12,761	24,118	16,158	30,413
Randolph	193,482	314,864	483,800	742,578
Ray	292,442	590,000	317,134	619,303
*Other counties	296,516	683,651	389,202	814,865
Small mines	113,506	228,205	109,116	225,528
Totals	3,188,965	$5,814,381	3,971,768	$6,918,578

* Including Caldwell, Carroll, Cass, Clay, Cole, Dade, Grundy, Harrison, Howard, Johnson, Livingston, Moniteau, Montgomery, Platte, Saline, Schuyler, Sullivan, and Vernon counties.

In 1911 Lafayette county assumed first rank in production, exceeding the output of Macon county by about 100,000 tons. The Lexington coal seam mined in Lafayette county varies from 16 to 22 inches in thickness while the Bevier seam of Macon county is from 4 to 6 feet in thickness. The production of Platte county is raised through shafts at Leavenworth, Kansas, mining extending beneath the Missouri river.

One of the important newly developed areas occurs at Cainesville, Harrison county. Drilling near Princeton and Cainesville has shown several seams of coal. A four-foot bed at a depth of 480 feet has been operated by the Grand River Coal and Coke

Company and extensive mining operations started. This development extends the productive area much further to the northwest than heretofore and indicates the occurrence of commercial coal seams in those counties underlain by the upper Coal Measures. The Bureau of Geology and Mines has recently published a complete report showing in detail the occurrence of the various coal seams throughout the State.

COBALT AND NICKEL:

Both cobalt and nickel ores occur near Fredericktown in Madison county. The deposits are not being operated at present, although for several years formerly there was a considerable production from this district.

These metals occur with both copper and lead ores, the complex nature of the deposits requiring a complicated reduction works.

COPPER.

The production of copper in Missouri in 1911 was 640,411 pounds, valued at $80,051, as compared with 94,452 pounds, valued at $11,955, in 1910. The entire output was obtained from the Disseminated Lead district where this metal is recovered as a by-product in the concentration of lead ore. Such recovery has only been practiced during the past two years, prior to which the copper was lost with the tailings from the lead mills.

While the mines near Fredericktown are kept in condition for working there has been no active mining on the properties for several years.

The Cornwall Mine in Ste. Genevieve county is being put in condition for operation and will no doubt be credited with a production during 1913.

The Copper Mountain Copper Company report additional ore on their property southeast of Sullivan and expect to put their copper smelter in blast during the next few months.

In Shannon county what is known as the Jerk Tail property has been discovered and prospect work is now being carried on. The property has a good showing at the present time.

During 1911 there has been more interest manifested in the production of copper than for many years.

IRON ORES.

During the past biennial period there has been a considerable

decrease in the mining of iron, due primarily to the closing of the stocks of the St. Louis Blast Furnace Company. As this furnace supplied the only available outlet for the ores mined in Wayne and adjoining counties of southeast Missouri, the mining properties of that district have since been closed. Mining has been carried on chiefly in the Central Ozark region where the ores produced are consumed by the Sligo Furnace at Sligo, Missouri. Pilot Knob has been active during most of the period, the output being shipped to smelters in Ohio.

The total production in 1910 was 8,341 tons, valued at $168,697, while in 1911 the output was 72,788 tons, valued at $153,676. The output is chiefly hematite.

This Bureau has recently issued a complete report covering the iron ores of the State. This report shows that the mining industry is in no way commensurate with available tonnage.

The chief districts contain many undeveloped ore bodies aggregating millions of tons of ore, most of which is minable under present commercial conditions. The brown ores of southeast Missouri, which are at present virtually undeveloped, are shown to be equal if not superior to the brown ores of Alabama and other southern states.

LIME.

The following table shows the value of the lime burned and the various purposes for which it was used:

PRODUCTION OF LINE FOR 1910 AND 1911.

Purpose sold for	1910	1911
Commercial	$688,515	$438,908
Alkali works	....	665
Agricultural	154	12,696
Chemical works	14,765	27,024
Sugar factories	1,370	14,080
Tanneries	2,025	1,800
Hydrate	49,625	66,335
Miscellaneous	89,689	227,390
Totals	$846,143	$788,898

The output was burned chiefly from limestone derived from the Burlington, Kimmswick, and Spergen formations, the more important plants being located in Greene, Lawrence, Marion, Pike, St. Louis, Jefferson, Ste. Genevieve, and Cape Girardeau counties. The output consists of high calcium lime exclusively. The dolomites

occurring in the State being too impure for use in the manufacture of magnesian lime.

The lime burned in the vicinity of St. Louis is rather dark in color and is known as black lime. Although a very strong lime it cannot be used for finishing purposes. A large tonnage is consumed annually in the purification of the water-supply of the city of St. Louis.

Although there has been a slight decrease in the output during the past year, Missouri still ranks fourth among the states in total production.

LEAD AND ZINC.

According to figures collected by the Federal Geological Survey the value of the concentrates of lead and zinc produced in Missouri for 1910 and 1911 was as follows:

	1911		1910	
	Tons	Value	Tons	Value
Lead ore	258,240	$12,469,260	248,058	$11,286,750
Zinc ore	237,931	9,157,979	256,167	9,903,942
Totals	496,171	$21,528,239	504,225	$21,190,692

The total value of the metallic lead and zinc obtained from the above concentrates was $30,064,830 in 1911 against $28,165,020 in 1910.

Approximately five-sixths of the entire output of lead concentrates is obtained from the Disseminated Lead District of Ste. Genevieve, Madison, and Washington counties. The ore of this area occurs in large blanket-like deposits in which the galena is disseminated through dolomite. The grade of ore will usually run from 3 to 6 per cent, probably averaging less than 4 per cent. In 1911 approximately 4,000,000 tons were hoisted.

Considerable prospecting has been done in the southern part of the district and in the vicinity of the producing mines. The Valley Mining Company have drilled a number of deep holes at Valley Mines, which is located north of the present disseminated lead district. During the past year the Cathering Mine, located near Fredericktown, has been re-opened by the Federal Lead Company. This mine was formerly operated by the Madison Lead and Land Company. The Doe Run Lead Company are erecting an

additional section to their mill No. 3, the mill at Doe Run having been closed down. Shaft No. 12 at Doe Run has also been closed temporarily. The magnetic plant of the Federal Lead Company which was burned in October 1912, will be rebuilt.

The enlargement of the Doe Run mill will materially add to the milling capacity of the district, the output of which has continually increased during the past ten years.

The zinc concentrates, with the exception of less than 700 tons, was obtained from the mines of southwest Missouri. Approximately 8,000,000 tons of dirt were hoisted, the average content being less than 4 per cent concentrates. The sheet ground averages less than 2.5 per cent, while the shallow deposits average about 4 per cent. There is a much greater variation in the value of the dirt hoisted in this district than in the Southeast Lead District. In the latter area ores seldom run over 6 per cent while in the Joplin area mines are frequently opened that will produce dirt running from 10 to 25 per cent ore. The shallow and pockety deposits of the southwest district also show a much greater variation in this regard than does the sheet ground where the mineralization is much more uniform.

During 1912 an exceedingly stable market and high price has stimulated production and the output for the year just past will exceed in value that of any former year.

MINERAL PAINTS.

During 1911 Missouri produced 28,201 short tons, valued at $2,034,339. The production for 1910 was 25,799 short tons, valued at $1,808,872. Compared to the output in 1910, the production in 1911 represents an increase in value of $225,467, or about 12 per cent.

The above figures only include natural mineral pigments and those manufactured directly from minerals or ores. They do not include the value of the white lead produced by the old dutch process of corroding metallic lead.

The output includes sublimed white lead, sublimed blue lead, litharge, ochers, venetian red mineral primers, and whiting. These pigments are obtained through the utilization of lead ore, zinc ore, ferruginous clays, iron ore, and limestone.

A pigment known as "Formastat" is being produced from specular iron ore mined about 6 miles south of Doe Run. The ore

occurs in very fine block flakes filling fissures in the granite country rock. The pigment is recommended as a covering for steel structures, especially those exposed to corroding influences. By special treatment the product is given a gold, silver gray, or copper color.

MINERAL WATERS.

But comparatively few of the mineral springs and wells within the State are utilized in a commercial way. At the present time there are less than thirty producers; the total output in 1910 being 637,035 gallons, valued at $96,488. In 1911, there was utilized 542,892 gallons, valued at $86,747. In addition to the above, less than 500,000 gallons are used each year for carbonated soft drinks.

The following springs are among the important producers:

McAllister Springs	McAllister, Mo.
Carrollton Spring	Carrollton, Mo.
ElDorado Springs	ElDorado Springs, Mo.
Lithum and Soda Springs	Excelsior Springs, Mo.
Cusenberry Springs	Kansas City, Mo.
Lithia Springs	Mt. Washington, Mo.
White Springs	Independence, Mo.
Bokhert Spring	DeSoto, Mo.
Wyoconda Spring	LaGrange, Mo.
Haymaker Spring	Lineville, Mo.
Nec Rock Spring	Burlington Junction, Mo.
Eagle Spring	Louisiana, Mo.
Kalinat, Lithia, and B. B. Springs	Bowling Green, Mo.
Belcher Artesian Well	St. Louis, Mo.
Blue Lick Springs	Blue Lick, Mo.
Sweet Springs	Sweet Springs, Mo.

PETROLEUM AND NATURAL GAS.

The output of petroleum and natural gas is obtained from shallow wells in Bates, Cass, and Jackson counties. Only one producer reports a production of petroleum in 1911, the output being valued in excess of $5,000.

The gas from 38 wells is reported to have been utilized in 1911, the total output being valued at $10,496. The production was confined to three counties; distributed as follows:

Bates county	$4,683
Cass county	1,075
Jackson county	4,778
Total	$10,496

Shallow wells in Clay and Clinton counties encountered gas, but due to improper casing water has accumulated in these wells and practically shut off all flow.

SILVER.

The lead ores of southeast Missouri contain a small amount of silver which averages about one ounce per ton of concentrates.

Through refining processes this silver is recovered at certain smelters. A large proportion of the output, however, is not subject to special treatment.

The recovery in 1910 was valued at $17,872 against a value of $26,430 in 1911.

SAND AND GRAVEL.

The sand and gravel produced in 1911 was valued at $1,042,674 as compared to $1,343,679 in 1910. The following table shows the value of the sand and gravel used for various purposes.

	1910	1911
Glass sand	$130,686	$82,705
Grinding sand	73,205	55,884
Molding sand	42,787	49,522
Building sand	571,501	533,722
Fire sand	16,420	2,371
Engine sand	12,544	14,000
Furnace sand	4,160	2,550
Paving sand	400	15,364
Miscellaneous	6,023	27,293
Gravel	485,953	259,263
Totals	$1,343,679	$1,042,674

Glass sand is obtained exclusively from the St. Peters sandstone which occupies a narrow belt in the eastern portion of the State extending from Callaway to Cape Girardeau counties. Pacific and Crystal City are the chief quarrying centers.

A large part of the building sand and gravel is obtained by dredges located along the Missouri and Mississippi rivers. The beds of these streams afford an inexhaustible supply of these materials.

PYRITE.

The Rock Island Mining Company at Leslie, Franklin county, was the only firm reporting sales of pyrite in 1911. The Pyrite Mining Company started operations at Vineland, Jefferson county, on December 15 of that year.

TRIPOLI.

The value of the output of tripoli in 1910 was $71,978 against $72,701 in 1911. Practically the entire production comes from Newton county.

Missouri tripoli consists of chert, which through partial decomposition has become very porous. It occurs in beds and boulders which are quarried and utilized in the manufacture of abrasives and water filters. At present the industry is restricted to the vicinity of Seneca and Racine.

ZINC.

(See Lead and Zinc)

FINANCIAL STATEMENT FOR 1911 AND 1912.

FINANCIAL STATEMENT FOR 1911 AND 1912

SUPPORT APPROPRIATION

1911

Buehler, H. A.	$3,820.96	
Hughes, V. H.	1,623.72	
Crane, G. W.	1,593.61	
Greene, F. C.	1,564.92	
Lee, Wallace	1,284.15	
Albertson, M.	765.84	
Illinski, A. X.	955.96	
Hirdler, E. E.	300.00	
Morse, Wm. E.	270.00	
Campbell, J. B.	350.00	
McCourt, W. E.	750.83	
Gottschalk, V. H.	232.85	
Bennett, John	614.00	
Kelly, M. J.	143.56	
Morris, E. R.	150.00	
Wilson, M. E.	382.72	
Hall, E. B.	321.41	
Ford, H. P.	182.92	
McNutt, V. H.	319.62	
Office and miscellaneous expenses	984.57	
Board Members	120.64	
Hugh Stephens Printing Company	61.39	
Postage	200.00	
Total		$16,993.67

1912

Buehler, H. A.	$3,563.61	
Hughes, V. H.	1,740.46	
Crane, G. W.	1,351.27	
Greene, F. C.	1,548.35	
Lee, Wallace	1,169.41	
Albertson, M.	1,334.35	
Illinski, A. X.	895.00	
Hirdler, E. E.	800.00	
Stimson, Gertrude C.	262.00	
Morse, Wm. E.	300.00	
McCourt, W. E.	336.42	
Gottschalk, Chas.	225.00	
Gottschalk, V. H.	125.00	
Rowley, R. R.	140.96	
Killian, Ralph	94.19	
Greger, D. K.	239.95	
Office and miscellaneous expenses	1,489.21	
Board Members	62.27	
Mound City Engraving Company	386.37	
Hugh Stephens Printing Company	2,024.89	
Gast Bank Note Company	1,340.82	
Buxton & Skinner	598.25	
Topographic Engraving Company	322.00	
Library of Congress	134.53	
Hunter, John	101.08	
Schuman Brothers	55.23	
Remington Typewriter Company	105.00	

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

TO THE

Forty-Eighth General Assembly

1915

MISSOURI BUREAU OF GEOLOGY AND MINES

H. A. BUEHLER, Director and State Geologist, Rolla, Mo.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

TRANSMITTED BY THE

BOARD OF MANAGERS

OF THE

BUREAU OF GEOLOGY AND MINES

TO THE

Forty-Eighth General Assembly

1915

THE HUGH STEPHENS PRINTING COMPANY
JEFFERSON CITY, MO.

HEADQUARTERS, MISSOURI BUREAU OF GEOLOGY AND MINES.

TABLE OF CONTENTS.

BOARD OF MANAGERS.

His Excellency, Elliott W. Major, Governor of Missouri, ex officio President of the Board, Jefferson City.

Hon. Elias S. Gatch, Vice-President, St. Louis.

Major Clark Craycroft, Secretary, Joplin.

Prof. E. M. Shepard, Springfield, chairman of Publication Committee.

Hon. Philip N. Moore, St. Louis.

LETTER OF TRANSMITTAL.

Rolla, Mo., Dec. 31st, 1914.

To the President, Governor Elliott W. Major, and the Honorable Members of the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to submit herewith a report on the work of the Bureau of Geology and Mines for the years 1913 and 1914.

It is my pleasure at this time to acknowledge my appreciation of the deep interest which the members of the Board have manifested in the work, and also to acknowledge the hearty co-operation extended the survey by citizens in every part of the State.

Respectfully,

H. A. BUEHLER,

State Geologist.

WORK OF THE BUREAU OF GEOLOGY AND MINES DURING 1913 AND 1914.

The following brief summary indicates the character of the field work and the general activities of the Bureau of Geology and Mines during the past biennial period.

The work, as stipulated by the law governing the department, (see appendix), may be summarized under the following heads:

(1) To determine the thickness, character, structure, distribution and geologic relations between the various rock formations underlying the State.

(2) To study the geologic occurrence and examine the various deposits of metallic and non-metallic mineral resources, including lead, zinc, iron, lime, cement, copper, barytes, sand, mineral waters, etc., and issue full and complete reports covering these subjects.

(3) To assist and guide development by acting as a reliable information bureau, giving correct information to all inquiries, examining all specimens sent the Bureau, and reporting upon their probable value.

(4) To visit individual properties upon the petition of fifty freeholders and recommend methods of prospecting and development.

(5) To enter into co-operation with Federal and State Bureaus where such co-operation will be of mutual benefit.

(6) To maintain a museum illustrating the geology and mineral resources, and collect and distribute mineral collections for the use of colleges and other schools.

Personnel:—The present staff of the Bureau includes the following members:

H. A. Buehler	State Geologist.
F. C. Greene	Geologist.
Otto von Schlichten	Geologist.
Stuart St. Clair	Geologist.
M. E. Wilson	Geologist.
G. B. Corless	Geologist.
Wm. C. Hogoboom	Asst. Geologist.
A. F. Truex	Asst. Geologist.
Sidney Reich	Chemist.

Mr. F. L. Johnson, chief clerk; Miss Lola Mitchell, stenographer; and Wm. E. Morse, janitor, are employed at the office.

During the field season a number of temporary assistants have been employed; men who are regularly engaged in university or college teaching, and devote the summer only to Survey work. The investigations, carried on in this way during the present biennial period, include the mapping in (1) Warren and Montgomery counties, by E. B. Branson and party, (2) Ste. Genevieve and Perry counties, by Mr. Stuart Weller and party, and the study of the sand and gravel deposits, by Mr. C. L. Dake. During the past year Prof. V. H. Gottschalk has carried on additional experiments covering the oxidation, transfer, and deposition of lead and zinc ores.

The personnel of the scientific staff has changed materially during the past two years; in fact, only one member of the present force was employed at the beginning of the biennial period. A majority of the resignations has been due to better financial offers on the part of mining companies and other geological surveys.

The value of an assistant depends to a considerable extent upon his knowledge of the geology of the State. The more familiar he is with the character and distribution of the various geologic formations, the more rapidly will he be able to get results and the more accurate will be his determinations. In dealing with economic problems, which may involve large expenditures, it is important that men of experience be employed. It is not easy to replace men who have served several years on the Bureau and who have a knowledge of the geology of the State due to this service.

With the present maximum salary limit of eighteen hundred dollars per years, it is impossible for the Bureau to meet the inducements held out by commercial interests and other surveys. Men with experience and special training can command larger salaries than the present law will permit this Survey to pay. This law was formulated some 25 years ago, and should be so changed as to meet present conditions.

Co-operation.

There has been the closest and most cordial relations and co-operation between this Bureau and the Federal Geological Survey, Federal Bureau of Mines, and adjoining State Geological Surveys.

Co-operation has continued with the Federal Geological Survey in topographic mapping. With the increased funds avail-

able during this biennial period more work has been accomplished than during any previous two years. Mr. W. H. Herron, Geographer for the central division, has been in active charge of the field surveys, the location of the areas to be mapped being determined by the Board of Managers of this Bureau in conference with representatives of the Federal Survey.

In addition to the above work, co-operation has continued in the study of the stratigraphy of the coal fields, and in the collection of mineral statistics. The mapping of the Mississippian formations in Ste. Genevieve and adjoining counties was also done in co-operation; the Federal Survey desiring to publish folio text on this and adjoining territory in Illinois. We have compiled with the Federal cartographers an accurate base map of the State on a scale of 1,500,000, or approximately eight miles per inch.

During the past year formal co-operation has been entered into with the United States Bureau of Mines. The Federal Bureau is making a study of the losses incident to mining and milling in Southwest Missouri, with special reference to possible saving in milling, and Mr. C. A. Wright of that Bureau has been investigating the possibilities of oil flotation and other treatment of tailings. The State Survey is assisting by the determination of the character of the ore and gangue which varies materially in the different camps throughout the district.

The neighboring State Geological Surveys have been most cordial in their co-operation on problems pertaining to the nomenclature of the formations of the Coal Measures, and in their contemporaneous studies of the Mississippian formations. The various states of the Mississippi Valley in which these formations occur, and the Federal Geological Survey are now combining in their study of these and other formations in order that duplication of work may be eliminated and more concordant results obtained. These co-operative features are of the greatest importance to thorough and accurate work.

Information Bureau.

A Bureau of this character is maintained that the State may assist in the development of its natural resources, and the Survey acts as a reliable source of information covering the occurrence and development of the various mineral deposits, including lead, zinc, coal, clay, iron, barytes, copper, tripoli, stone, lime, cement, mineral waters, etc.

Each field investigation is undertaken for the purpose of obtaining the facts upon which to base correct deductions.

At no former time has there been as great a demand for the services of the Bureau as during the past biennial period. Information is distributed in three ways, (1) by correspondence, (2) by the distribution of reports and maps, (3) by personal visits.

The correspondence of the Bureau includes the answering of requests for information covering every phase of our mineral industry; not only do citizens of the State avail themselves of the privilege, but investors throughout the entire country continually ask for information and reports.

The distribution of reports and maps indicate something of this desire for information. During the past two years over 4,200 geologic reports have been sent out, 2,500 State maps and 1,500 Biennial reports. In addition there have been many requests for the earlier reports which are now out of print, and which can only be obtained through second-hand book stores.

The law specifies that upon receipt of a petition signed by 50 freeholders a member of the Survey shall examine and report upon property designated in said petition. We have answered all such requests and in addition have made trips in answer to personal letters where it appeared that the service of a member of the Survey would assist in developing a district or would stop useless expenditures in prospecting where there is no hope of financial returns.

Among the important pieces of field work undertaken or completed during the biennial period are the following:

Formations of the Coal Measures.

In co-operation with the Federal Geological Survey the Bureau issued, in 1912, a report covering the general occurrence, character and distribution of the coal deposits of the State. Incident to the preparing of this report a rather detailed study was made of the formations comprising the coal measures. This material has been published during the present year, the volume including chapters on the general distribution, and character of the coal measures, and their occurrence in each county. As more than one-third of the State is underlain by these formations, the importance of this study from an economic and scientific standpoint will be appreciated.

The coal measures probably offer the chief hope for possible returns in prospecting for oil and gas, and a knowledge of the

succession of these formations furnishes a key to the depth and position of the various sands. The folding of the beds, now recognized as one of the chief factors in the accumulation of oil and gas, is dealt with in the text as well as shown by structure maps which outline the principal anticlines and synclines.

The question of the nomenclature of the Pennsylvanian series of the Missouri Valley has been under discussion for many years. In this work the Survey has endeavored to unify the formation and member names and has brought into accord as far as possible the Iowa, Nebraska, Kansas, Missouri, and Federal Surveys.

Rolla Quadrangle.

The report covering the Rolla quadrangle was published in 1913. It describes the geology and topography as well as the mineral resources of the area. The formations described in this report occur throughout a large part of the central Ozark region, and the volume may be used as a key to the study of surrounding areas.

Base Map.

The Bureau compiled, in co-operation with the Federal Geological Survey, a base map of the State on a scale of 1:500,000 or approximately 8 miles per inch. This map is based on original land surveys which have been adjusted to accurate positions established by the Coast and Geodedic Survey, the Mississippi River Commission, the Missouri River Commission, and the United States Geological Survey. Railroads, cities, towns and streams are accurately located, while the elevations of all permanent bench marks at cities, and the approximate elevations of all railroad stations, where data could be obtained, are shown. The map is by far the most accurate ever compiled and should be in every school room in the State.

Lead and Zinc.

The work of the Bureau in the lead and zinc fields during the past two years has been largely restricted to the Joplin district and differs somewhat from the general methods employed in the past. Heretofore there has been no special effort made towards preserving accurate records covering drilling or prospecting. As a consequence, it is not possible to get information covering thousands of holes already drilled and duplication of work is a common

thing in the district. The geologic and topographic maps of the region are not on a sufficiently large scale to be of value in locating prospects or other local features of importance to the miner.

During the past year the Bureau has established a branch office in Joplin and assistants are now actively engaged in visiting the drills of the district and making accurate logs of all holes. Cuttings are collected and type records are preserved in glass tubes where they can be examined at any time. In conjunction with this work, mapping on a four-inch scale is being carried on in the Thoms Station district north of Joplin and west of Webb City. This scale is of sufficient size to show land ownership, the location of mines and prospects, as well as detailed topography.

In this work we have obtained the hearty co-operation of the drillers, land owners, and miners. The value of the results will grow as the work continues.

County Reports.

During the present biennial period county mapping has been completed in Ste. Genevieve, Platte, Mercer, and Grundy counties, and the reports are at present being prepared for publication. The total area comprises 1804 square miles; a greater territory than has been mapped during any previous biennial period.

Ste. Genevieve County.— Containing representatives of every geologic formation occurring in the State, below the coal measures, Ste. Genevieve County is one of the most important areas from a stratigraphic standpoint, and the real key to the geology of Southeast Missouri.

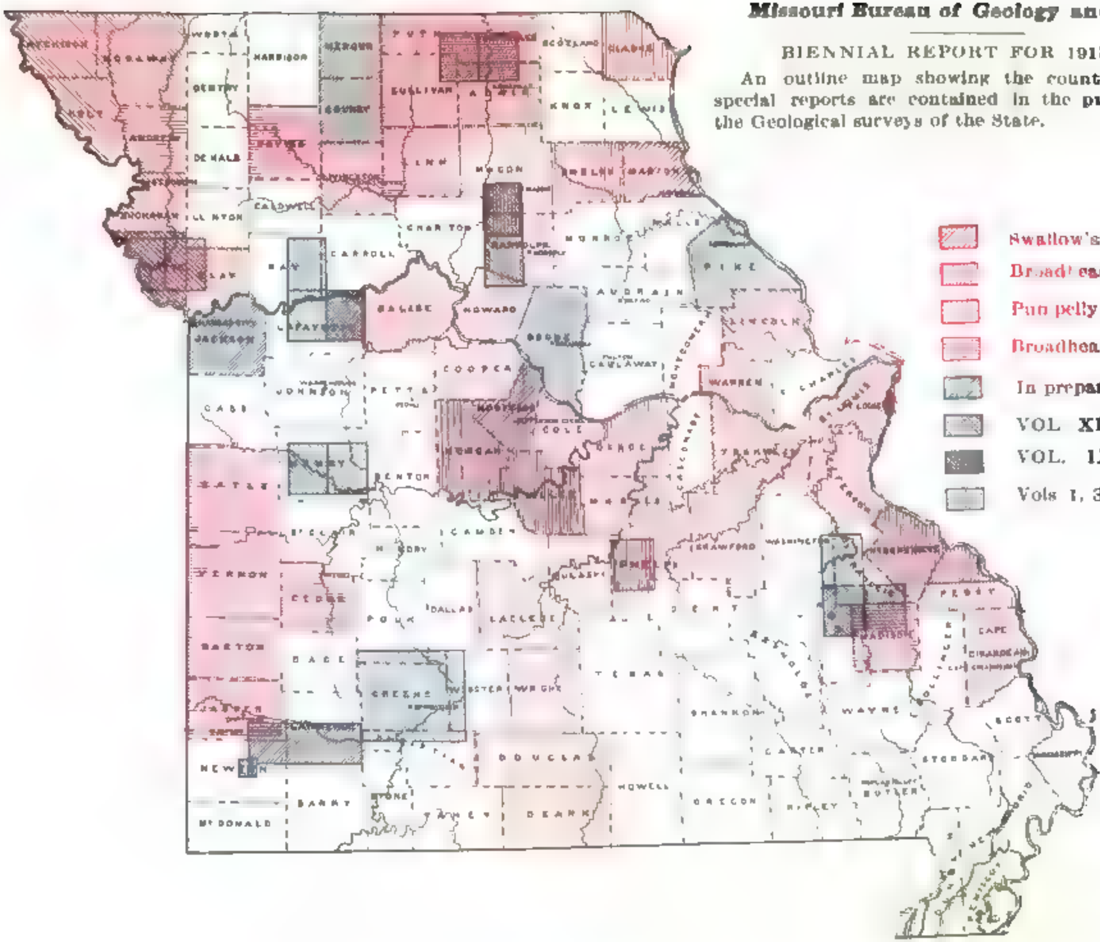
The rocks dip rapidly eastward bringing a succession of formations to the surface in a short distance. This structure is complicated by an important strip of faulting which strikes diagonally across the county from northwest to southeast, exposing many formations that could not otherwise be seen. This faulted zone is now shown to be the southeast extension of the Valle Mines French Village fault, and is a part of the same general faulted area extending southeastward into the fluorspar region of Illinois and Kentucky. It is one of the most complicated and extensive fault zones in the Mississippi Valley.

The Bonneterre dolomite which is exposed in the western part of the county is known to carry some lead. The St. Peter sandstone has sand suitable for use in the manufacture of plate glass, and the limestones of the eastern part of the county have

Missouri Bureau of Geology and Mines

BIENNIAL REPORT FOR 1913-1914.

An outline map showing the counties of which special reports are contained in the publications of the Geological surveys of the State.



Swallow's Report of 1855

Broadhead's et al. Reports of 1871

Pumpelly's Report of 1872

Broadhead's Report of 1873

In preparation

VOL. XII } 1st Series
VOL. IX }

Vols 1, 3, 4, 7, 8, 9, 12, Sec. Series.

long been used for riprap and in the manufacture of lime. The sandstone on Aux Vases Creek was quarried and used in the construction of Eads Bridge. At the present time important quarry developments north of Ste. Genevieve indicate the opening of ledges that will produce cut stone equal in every way to the Bedford stone of Indiana.

Platte County.—The mapping of Platte County both topographically and geologically was completed in 1914, and the report will probably be ready for publication during the coming year. The underlying rocks belong to the coal measures or Pennsylvanian formations, which contain coal beds of commercial importance. Recent drilling near Parkville has given promise of natural gas development.

Much of the coal hoisted through shafts at Leavenworth, Kansas, is mined under Platte County (over 100,000 tons in 1913). The same bed has been found by drilling both north and east of Leavenworth, indicating its presence under a large portion, if not the whole of Platte County. This bed, which is not over 500 feet deep near Parkville and even less to the east, should prove of great future commercial value in view of the large market furnished by Kansas City.

Several wells drilled near Tiffany Springs in 1914 encountered gas, and a pipe line is now being constructed to Parkville. Three of the wells are said to have flows of 300,000, 600,000, and 1,000,000 cubic feet per day respectively. The gas-bearing sand lies about 550 feet below the surface.

It is a well recognized fact that the structure or "lay" of the rocks has much to do with the accumulation of oil and gas. The rocks of Platte County dip gently to the northwest, but this dip is modified by low arches or anticlines and troughs or synclines, also by structural terraces where the rocks are nearly flat. The oil or gas usually rises to the top of the arch or occurs on terraces and salt water is generally found in the trough. This being the case, the mapping has been directed toward determining the structure with a view of assisting in the proper location of new drilling. Though none of the anticlines are very large, a fairly well defined one lies three miles north of Smithville, extending from Camp Creek northwestward into Platte county, to the Rock Island Railway, where it dies out. Another well marked anticline extends northwestward from Settle's Station, on the Rock Island line, to a point half way between Weston and Iatan, dying out just before it reaches the bluffs of Missouri River. As

these anticlines plunge to the northwest, the location most favorable for obtaining oil and gas are probably toward the southeast end and along the various terraces.

The maps accompanying the report will show these structural features in detail, as well as the distribution of the various limestones, shales, sandstones and other rocks.

Grundy and Mercer Counties.—The field work covering a report on these counties has been completed and the report is being written.

Prospecting by means of core drills has demonstrated the presence of a large coal field (the Cainesville bed) in Mercer County, and it may be said with safety that practically every square mile of both counties are underlain by at least one coal bed of workable thickness. The Cainesville coal occupies a basin stretching from Cainesville to a short distance south of Mt. Moriah and from Mill Grove to Lineville. The coal is more or less continuous between these four points and to an unknown but probably short distance to the south and east. It does not extend to Trenton, and wells between Trenton and Harris seemingly did not find it. Near Blythedale, about six miles west of Cainesville, a bed 46 inches thick, at a depth of 622 feet, is probably the Cainesville.

In the vicinity of Cainesville no partings divide the coal which ranges from 44 to 60 inches thick, commonly about 4 feet. If the Mt. Moriah log is correctly interpreted, the coal is split by partings, possibly an indication that the drilling was done on the edge of the basin. In all of the 12 drillings near Princeton of which records were obtained, the bed is split by a parting, including which the bed averages about 76 inches. The upper bench ranges from 11 to 34 inches, averaging 26 inches; the parting ranges from 2 to 44 inches, averaging 23; and the lower bench ranges from 12 to 37 inches, averaging 27 inches. At Lineville the parting increases; the upper bench is 33 inches and the lower 21 inches. The roof is chiefly a light or dark shale, the floor is clay or shale. The most favorable place for the development of this coal in Mercer County is in the valley of Grand River south of Princeton where it lies about 475 feet below the surface.

A coal bed (the Eureka) about 100 feet above the Cainesville has been reported 42 inches thick at a depth of 252 feet in a boring for water near Laredo. As this bed is fairly persistent in Linn and Macon counties, the Laredo field is worthy of investigation. The Lower Ardmore has also proven persistent under

much of the area of both counties and is usually 18 to 20 inches thick. It has been mined for years at Trenton and was formerly mined at Galt. The Lexington bed, about 24 inches thick, is present in a small area near Brimson, a larger area between Spickard and Mill Grove and possibly in the northeastern corner of Mercer County adjacent to Powersville where it has been mined. Though a few thin coal beds outcrop at the surface, the Lexington is the highest bed which is of commercial importance. The report will contain a detailed discussion of the thickness, depth and areal extent of the various coal seams.

The mapping of Grundy and Mercer counties has proven the existence of a large buried pre-glacial valley extending across the former. The sand now occupying the lower part of this valley contains an abundant supply of pure water which may prove to be artesian if the wells driven to it are situated at a sufficiently low elevation. A sandstone lying 400 to 500 feet below the surface in the southeastern part of Grundy County contains a large supply of salt water much sought after by stock raisers.

Underground Water Supply.

A thorough study of the underground waters of the State has been started during the past biennial period. The possibility of obtaining an adequate and pure supply from the underlying rocks depends chiefly upon the geologic formations and their relative position. Each is an independent factor in the matter of water supply, and a formation may vary within itself in a comparatively short distance as to the character and available supply of its waters.

At present many parts of the State are poorly watered, the source being chiefly ponds, cisterns or shallow dug wells. These surface supplies are always subject to contamination from organic sources, and are, therefore, a continual source of danger to the health of a community. In most instances an excellent supply might be obtained by drilling, and the present investigation is undertaken for the purpose of determining the character, depth and possible supply of the various water horizons underneath each county.

Drilling in the northern part of Warren County illustrates the failure of wells due to the local lack of knowledge regarding the geology of the region. Up to the last two years the supply has been obtained largely from ponds, cisterns, and shallow dug wells, all unsatisfactory during times of drought. In 1913 a few

wells were drilled from 225 to 375 feet in depth. Some produced a fair supply of good water; others only a slight amount. Most of these wells did not reach the best water horizon, the St. Peter sandstone which underlies the entire area, and which occurs at depths of from 400 to 500 feet. It offers a supply of from 10 to 15 gallons a minute of fresh, soft water. The above facts indicate that with a proper knowledge of the depth of the chief water horizons many poor wells could be made to produce an adequate supply with comparatively little extra cost.

The St. Peter sandstone offers a definite and reliable water horizon, although contrary to old beliefs this supply is not always large or good. It is from this sandstone that the water in the flowing wells in the tier of counties bordering Mississippi River is derived. It is now known that over a considerable part of Northeast Missouri the St. Peter sandstone cannot be relied upon for municipal supplies, and that over a rather well defined area, water, made nonpotable by the large amount of salt and sulphuretted hydrogen, can be expected from this horizon.

In the northern counties a thick deposit of glacial drift covers the surface. Here few wells reach the bed rock and an ample supply for domestic and stock use is obtained from the sand layers or lenses in or at the base of the drift. The water from these sources is usually of excellent quality, but varies in quantity with the season.

In the west central parts of the State the Pennsylvanian coal measures are largely drawn upon. The Cherokee shale lying at the base of the series is especially notable for the excellent water-bearing sandstones contained. In some localities, as in the western part of Lafayette County, their waters are too salty for use. In Johnson County these sandstones are very largely drawn upon with satisfactory results, while in Cass County the very meager results secured from drilled wells are in large part due to the failure to pierce the overlying limestones and shales in order to tap these lower sandstones.

In comparison, more wells have been drilled in the Ozarks than in the prairie region, this despite the abundance of fresh water springs. There are, however, few wells over 100 feet deep throughout the area, the limestone formations usually supplying the necessary quantity from comparatively shallow depths.

Artesian basins occur in many parts of the State. These are due to special structural features and the source or intake may be a long distance from the area showing flowing wells.

The above facts are mentioned here to indicate the value of an investigation of this character. The report will discuss the possibilities of each county in the State and will supplement the work done several years ago for the Federal Survey, by Prof. E. M. Shepard.

SAND AND GRAVEL.

Deposits of glass sand constitute one of the important non-metallic resources of the eastern part of the State. During the past biennial period, work was completed on the detailed mapping of the St. Peter formation from which the chief supply of glass sand is obtained. This sandstone, which averages between 75 to 100 feet thick, has been traced continuously from the southern part of Cape Girardeau County northward through Perry, Ste. Genevieve, Jefferson and Franklin counties to Klondike in St. Charles County. At this point it turns westward paralleling the river in the southern portion of Warren and Montgomery counties. At the east line of Callaway County this sandstone thins greatly, and pinches out or is buried under other formations. West of this point it is only known in small patches of little or no economic value. Sand for glass manufacture and foundry use is quarried from the formation at Crystal City, Festus, and Silica, in Jefferson County, in and near Pacific, in Franklin and St. Louis counties, and at Klondike, in St. Charles County. Field work has shown that the formation is capable of supplying unlimited quantities of excellent material at many points which are entirely undeveloped.

The leading plants producing river and bank sand and gravel for structural and other purposes were visited, and rather complete information secured concerning the source and character of the material obtained. On Mississippi River, sand pumping plants are located at Cape Girardeau, Crystal City, St. Louis, Louisiana, Hannibal, and Canton. On the Missouri, sand is dredged at St. Charles, Glasgow, Lexington, Kansas City, St. Joseph and Jefferson City. Plants on the Meramec dredge an excellent grade of sand and gravel at Pacific, Drake, Sherman, and Valley Park, most of the output being shipped to St. Louis. Black River furnishes sand and gravel at Poplar Bluff and Mill Spring. Gravel is dredged from Joachim Creek, near Festus. Piney Creek supplies sand to plants at Newburg and Arlington, in Phelps County. Osage River furnishes good roofing gravel, dredged at Osage City. Salt River gravel is dredged near New

London. Nodaway River sand is dredged at Maitland and Skidmore. Many other small creeks furnish good sand and gravel for local use, especially in the Ozark region. Bank sand and gravel are developed to some extent at Commerce, and at Pacific, Maryville, and Guilford. In a number of instances the sand and gravel produced might well be used for purposes other than structural. Engine sand, moulding sand, fire sand, and sand for filter beds usually require special characteristics. It is the purpose of the work to show the character of the products obtained from the various plants throughout the State.

In addition to the above field work Prof. E. B. Branson and party mapped the Devonian formations in Montgomery and Warren Counties and Prof. R. R. Rowley submitted manuscript covering the faunas of the Silurian formations of Northeast Missouri.

Chemical Laboratory.

The work in the chemical laboratory has been devoted largely to the analysis of material collected by members of the Survey and to the testing of samples submitted by residents of the State. The Bureau does not attempt commercial work or make chemical determinations for producing mines.

Museum and Library.

In connection with remodeling the Survey headquarters, the library and museum have been entirely rearranged and cataloged on a more systematic basis. Many specimens have been added to the museum from the counties in which areal mapping was completed, the cuttings of many deep wells have been obtained, and a complete set of sand and gravel samples were collected from producing plants. The specimens placed in the museum are chosen for the purpose of showing the general character of the rocks comprising the geological formations as well as their various economic materials. In addition to the museum at Rolla, an exhibit is maintained at the State Fair; the Director of the Bureau being in charge of the Department of Mines and Forestry.

The usual number of volumes have been added to the library through exchange with other scientific bureaus. These reports are received as a return courtesy for the volumes issued by the Survey.

TOPOGRAPHIC MAPPING.

The funds appropriated for topographic mapping have been spent in co-operation with the United States Geological Survey. In this work the Federal Survey pays one-half the actual field expenses, furnishes a trained corps of topographers and does the necessary engraving without cost to the State. The Board of Managers of the Missouri Survey, in conference with representatives of the Federal Bureau determines the quadrangles and areas to be mapped.

During the biennial period topographic maps have been completed of Platte and Ste. Genevieve counties and the former has been printed ready for distribution.

In addition to these areas field work was completed on the Sturgeon quadrangle northwest of Columbia, Boone County; the Neosho quadrangle in Newton County; the Missouri portions of the Kimmswick, Crystal City, Renault and Chester quadrangles extending along Mississippi River in St. Louis, Jefferson, Ste. Genevieve, and Perry counties. The area bordering the Mississippi is now mapped from north of St. Louis to Perryville in Perry County. Field work on the Eminence quadrangle in Shannon County is practically done and the primary traverse has been run on the Warrensburg sheet in Johnson County. The Green City, Queen City, and Smithville qudarangles were engraved and published. All work at present is done on a scale of one inch to the mile, with a contour internal of 20 feet.

One of the first problems in mapping an area is the determination of its exact location. This is accomplished by running careful traverse lines from known points already determined by other surveys. In order to adjust surveys which have been started at different points throughout the State, several important lines of traverse were run during this biennial period. (1) A line extending from the Smithville quadrangle in Platte through Clinton, Caldwell, Daviess, Grundy and Linn counties to the Green City sheet in Sullivan County. This line adjusts work started from bench marks on Missouri River with work started from points on the Mississippi. (2) A line connecting the Surveys in Camden County with the traverse of the St. Louis and San Francisco Railroad, was run from Linn Creek to Lebanon. (3) A line starting at Marshfield in Webster County was run southeast through Wright, Texas, and Howell to Eminence, Shannon County, then northeast to the western part of Reynolds County.

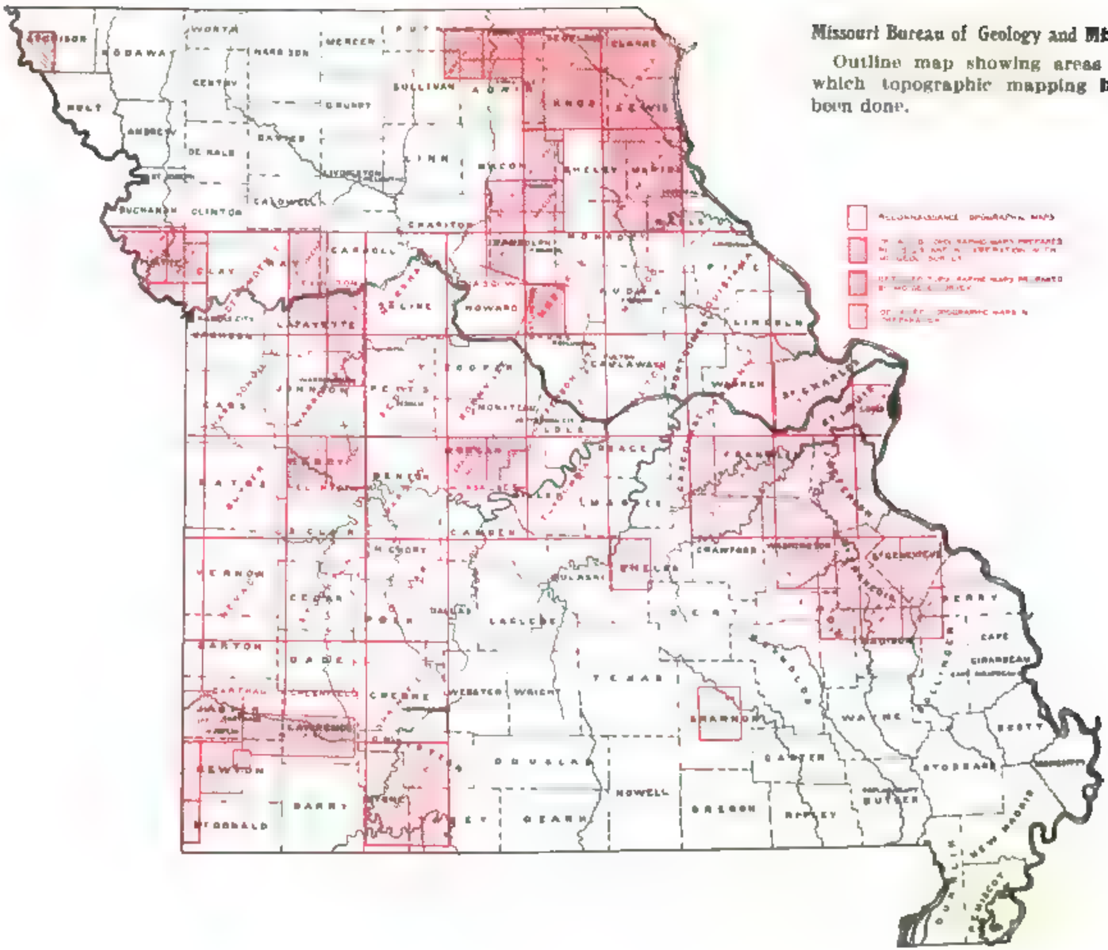
This line of traverse adjusts areas in the western and southern parts of the State with work started along Mississippi River. It forms a convenient base from which to start mapping at any point in South Missouri.

In order to get accurate elevations for mapping the Eminence quadrangle, a line of precise level was run from Cuba, Crawford County, southwest to Eminence, then eastward to bench marks on Mississippi River, connecting lines derived from the Missouri River Surveys with those of the Mississippi River Commission.

The following tabulation indicates the area mapped, miles of traverse, miles of levels, and permanent bench marks established during the biennial period:

Missouri Bureau of Geology and Mines

Outline map showing areas in which topographic mapping has been done.



FIELD WORK.

Quadrangles.	Counties.	For publication on scale of.	Area mapped sq. mi.	Primary levels.		Traverse.		
				Miles.	Per B. M's.	Primary miles.	Per Mks.	Secondary miles.
Crystal City	Ste. Genevieve	1:62,500	207	72	18	36	2	811
Renault	Ste. Genevieve	1:62,500	51	17	4	...	...	230
Knoblick	Ste. Genevieve	1:62,500	3	...	...	...	...	12
Armourdale	Platte	1:62,500	43	..	...	...	...	34
Dearborn	Platte	1:62,500	29	...	...	...	...	...
Sugar Lake	Platte	1:62,500	11	...	...	...	...	...
Waldron	Platte	1:62,500	5	...	...	...	...	...
Gower	Platte, Clinton, Buchanon	1:62,500	19	...	...	11	1	...
Sturgeon	Audrain, Boone, Howard, Randolph	1:62,500	156	...	...	...	...	583
Neosho	Newton, McDonald	1:62,500	239	101	29	43	3	496
Eminence	Shannon	1:62,500	166	91	25	69	5	817
Chillicothe	Grundy		...	...	...	60	4	...
Gallatin	Grundy, Livingston, Caldwell, Daviess		...	...	...	43	3	...
Gilman City	Grundy, Harrison, Daviess		...	...	...	7	1	...
Plattsburg	Clinton		...	...	...	18	2	...
Polo	Clinton, Caldwell, Ray		...	...	..	6	1	...
Trenton	Grundy		...	...	...	18	3	...
Winston	Caldwell, DeKalb, Daviess		...	...	...	16	2	...
Boynton	Putnam, Sullivan		...	...	...	9	1	...
Braymer	Caldwell, Carroll, Ray, Livingston		...	...	...	8	1	...
Chula	Livingston, Linn, Grundy		...	...	...	9	1	...
Dawn	Livingston, Carroll		...	...	...	8	1	...
Galt	Grundy, Linn		...	...	...	17	2	...
Lucerne	Grundy, Mercer, Putnam, Sullivan		...	...	...	7	2	...
Milan	Linn, Sullivan		...	...	...	9	...	...
Celt	Camden, Dallas		...	...	...	4	1	...
Lebanon	Laclede		...	...	...	6	1	...
Long Lane	Laclede, Dallas		...	...	...	15	2	...
Niangua	Laclede, Dallas, Webster		...	...	...	22	2	...

FIELD WORK.

Quadrangles.	Counties.	For publication on scale of.	Area mapped sq. mi.	Primary levels.		Traverse.		
				Miles.	Per B. M's.	Primary miles.	Per Mks.	Secondary miles.
Passover	Camden, Miller, Morgan		...	...	...	5	...	...
Sleeper	Camden, Laclede		...	...	...	17	2	...
Exchange	Caster, Reynolds, Shannon		...	...	...	28	2	...
Monteer	Oregon, Shannon, Howell		...	...	...	15	2	...
Corridon	Reynolds, Shannon		...	...	...	3	..	...
Willow Springs	Howell		...	...	...	17	3	...
Cedar Gap	Douglas, Wright, Webster		...	...	...	17	2	...
Cabool	Douglas, Howell, Texas		...	...	...	22	2	...
Macomb	Douglas, Wright		...	...	...	16	3	...
Maysville	DeKalb		...	...	...	7	1	...
Redford	Reynolds		...	...	...	19	1	...
Ruble	Reynolds		...	...	...	3	1	...
Fordland	Christian, Douglas, Webster		...	...	...	19	4	...
Ritchey	Newton, Barry, McDonald		...	...	...	10	...	...
Joplin District	Newton, Jasper		...	...	...	17	2	...
Summerville	Shannon, Texas, Howell		...	...	...	14	1	...
Noel	McDonald		...	...	...	10	1	...
Wyandotte, Spec.	McDonald, Newton		...	...	...	4	...	...
Harrisonville NE ¼	Cass, Jackson, Johnson		...	...	...	12	1	...
Knobnoster	Johnson, Lafayette		...	...	...	55	3	...
Lexington, SE ¼	Lafayette		...	...	...	6	1	...
Lexington, SW ¼	Lafayette		...	...	...	8	...	...
Sedalia, NW ¼	Saline, Pettis		...	..	...	10	3	...
Warrensburg, NW ¼	Lafayette, Johnson		...	...	...	54	5	...
Warrensburg, SE ¼	Henry, Johnson		...	...	...	6	1	...
Warrensburg, SW ¼	Henry, Johnson		...	...	...	7	1	...
Sinkin	Shannon, Dent		...	22	7	6	...	...
Salem	Dent		...	17	4	...	...	...
Steelville	Dent, Crawford		...	27	9	...	...	...
Bandyville	Oregon, Shannon		..	5	1	8	2	...

Cuba	Gasconade, Crawford, Franklin		...	7	2	...	..	...
Stone Hill	Crawford, Dent, Reynolds		...	10	3	...	...	...
Low Wossie	Carter, Oregon, Shannon Ripley		...	18	6	...	...	...
Upalika	Carter, Butler, Wayne, Ripley		...	16	5	...	...	...
Puxico	Stoddard, Butler, Wayne		...	13	4	...	...	...
Grandin	Carter, Ripley		...	20	6	...	...	...
Greenbrier	Bollinger, Wayne, Stoddard		...	6	2	...	...	...
Hendrickson	Butler, Wayne		...	21	6	...	...	...
Advance	Bollinger, Cape Girardeau, Stoddard		...	14	4	...	...	...
Cape Girardeau	Cape Girardeau		...	11	2	...	...	...
Morley	Cape Girardeau, Scott		...	14	5	...	...	...
	Total, cooperative		929	502	142	856	85	2983

NON-COOPERATIVE FIELD WORK.

Perryville	Perry		...	...	...	9	1	...
Chester	Ste. Genevieve, Perry	1:62,500	160	46	23	10	1	494
Kimmswick	Jefferson	1:62,500	67	63	16	25	1	217
	Total, non-cooperative		227	109	39	44	3	711
	Total		1156	611	181	900	88	3694

FUTURE WORK.

The following table indicates the phenomenal development of our mineral resources during the past fifteen years.

MINERAL PRODUCTION FOR 1898 AND 1913.

Commodity.	1898	1913	Per cent increase.
Lead	$3,011,055	$11,444,935	279
Zinc	2,927,321	9,664,423	230
Coal	3,148,826	7,468,308	137
Clay and clay products	3,256,207	7,072,353	117
Cement (portland)	None	4,556,822	...
Building stone	437,874	2,538,699	481
Mineral paints	No data	2,359,592	...
Sand and gravel	No data	1,109,233	...
Lime	297,401	734,009	147
Chats	No data	304,333	...
Barytes	61,875	117,638	90
Copper	None	89,312	...
Mineral waters	59,341	84,316	42
Tripoli	No data	83,995	...
Iron ore	123,345	83,628	32
Silver	None	21,514	...
Natural gas	None	6,795	...
Miscellaneous	...	20,679	...
Total	$13,323,245	$47,760,584	...

Each succeeding biennial period has shown a material increase in total output; the value, in many cases, doubling in from four to five years. With this development there has been a corresponding increase in demands upon the Bureau. The opening of any new deposit is always the occasion of many requests for maps and reports covering the geology of the surrounding region. The assistance and value of detailed information and maps is shown by the results of our work in Platte County. Recent drilling near Parkville has encountered gas in a fifteen foot sand at a depth of 530 feet. It is well known that most productive oil and gas pools occur along crests of folds in the rocks (anticlines), and that salt water is usually encountered in the troughs (synclines). With the bringing in of these wells there has been a demand from oil men for a structural map of the entire county.

During the past two seasons we have completed detailed topographic and geologic maps of this area and in answer to inquiries the Survey has been able to point out, (1) the location of all anticlines, (2) the general nature and succession of the formations to be penetrated, and (3) the depth of the Mississippian

limestone which usually limits drilling in the mid-continental field. Drilling is now being done along the anticlines located by the Bureau. The total cost of the field work for this report was but little more than the price of a single hole.

It is just such information as this that the Survey is endeavoring to supply for every county in the State; not only in regard to oil and gas, but for lead, zinc, iron, coal, tripoli, barytes, clay and building stone, and in fact, every mineral resource.

The work as planned for the coming biennial period includes additional county mapping and the further systematic study of those mineral deposits of which we do not now have reports.

The present work in the Joplin lead and zinc district will be continued. In addition, mapping should be done in the Madison County lead district in order that detailed maps may be had of the southern extension of the disseminated lead belt. The fissure deposits of Franklin, the shallow ores of Washington, and the deposits of the central district extending from Morgan and Moniteau counties to the Arkansas line, occur under quite different geologic conditions. The area covered by these various fields includes a large part of the Ozark region on which there are no reports, especially the southern part.

At the present time economic reports are available on coal, iron, cement, lime and building stone and reports are being prepared on the sand and gravel deposits, and underground waters. The resources of which there are no reports at hand include clay, barytes, copper, cobalt, nickel, tripoli, pyrites, mineral paints, and mineral waters. Each of these should be systematically studied as soon as possible.

In addition to economic studies, additional county reports should be prepared. At the present time volumes are available or in preparation covering Miller, Morgan, Moniteau, Pike, Platte, Ste. Genevieve, Jackson, Mercer, Grundy, and parts of St. Francois, Washington, Newton, Clay, Putnam, Schuyler, Sullivan, Adair and Phelps Counties. The reports covering other areas as shown on the accompanying map are out of print.

Reports similar to the one issued on the coal measures should be prepared for each of the other geologic divisions. Present plans look to a further study and mapping of the Mississippian and Devonian formations, and to a possible cooperative arrange ment with the Federal Geological Survey in a stratigraphic study of the entire Ozark region.

The answering of petitions and personal inspection of property upon the request of land owners, who wish if possible to

develop economic deposits, is a part of the work that continues to grow each year. Such visits are of importance, not only in pointing out favorable areas for prospecting, but frequently save useless expenditures where there is no hope of obtaining the mineral sought.

The value of the topographic maps is indicated to some extent by the demand for additional work of this character. During the past two years the Bureau has received requests from congressmen, commercial clubs, mining companies, and citizens for the mapping of over 10,000 square miles. This is approximately ten times the area that can be surveyed with the funds available and is almost as much as has been surveyed by the State and Federal Surveys since their organization.

Less than one-fifth of the State has been covered by accurate topographic maps, and in some cases the scale of these is too small to prove of the greatest usefulness. At the present time all maps are being made on the scale of one inch to the mile, with a contour interval of 20 feet. In the case of mining areas and drainage schemes this scale should be increased to show special features of importance. Old reconnaissance maps published by the Federal Survey about 20 years ago cover the central portion of the State as shown on the accompanying map. The following tabulation shows the areas already mapped. The maps are all on a scale of one inch per mile with 20 feet contour interval except: the Joplin and Aurora sheets which show contour intervals of 10 feet; the Forsyth, Sullivan, DeSoto and O'Fallon quadrangles; which indicate differences in elevation of 50 feet on a scale of one-half inch to the mile; and the Kahoka, Palmyra and Edina, having 20 foot differences in elevation with a scale of one-half inch to the mile.

	Square miles.		Square miles.
Atlanta	229	Kahoka	885
Aurora	550	Kimmswick	175
Bevier	230	Leavenworth	160
Bonneterre	236	Lexington	232
Calhoun	234	Macon	230
Campbell Hill	25	Mine Lamotte	236
Chester	158	Nemaha	114
Clinton	234	Neosho	239
Crystal City	210	O'Fallon	897
DeSoto	938	Palmyra	918
Edina	912	Platte County*	410
Eldon	234	Potosi	236
Eminence	238	Queen City	228
Farmington	236	Renault	50

	Square miles.		Square miles.
Forsyth	957	Richmond	231
Granby	15	Rolla	236
Gravois Mills	234	St. Louis	273
Green City	228	Smithville	231
Higdon	236	Sturgeon	232
Higginsville	232	Sullivan	938
Huntsville	231	Weingarten	236
Iron Mountain	236	Wyandotte	75
Joplin	340		
		Total	13,529
		*Includes 300 square miles of the Leavenworth and Smithville sheets.	

In order to continue the work of the Bureau and increase its service commensurate with the development of our mineral resources the following appropriation is urgently requested:

Support (including printing)	$57,000.00
Topography	30,000.00
Total	$87,000.00

Note. In Topographic Work the Federal Survey will co-operate with the State Survey up to a total expenditure of $15,000 per year or $30,000 per biennial period. During the past biennial period only half this amount was appropriated on the part of the Government as the State appropriated only $15,000. The State should appropriate the full amount in order to get the advantage of all the funds the Government will allot to this work.

THE MINERAL RESOURCES OF MISSOURI.

Production for 1912 and 1913.

In 1912 the value of the output of the mineral industries for the first time exceeded the fifty million mark, a figure over $5,000,000 greater than any previous year. The drop in the price of zinc during 1913 is largely responsible for the drop in total amount during that year. With the exception however of 1912 the production of 1913 is the largest in the history of the state.

The last biennial period therefore has shown the usual consistent advance over the previous period, the total increase being $7,500,000.

The following table shows the total value of the output for 1912 and 1913:

VALUE OF MINERAL PRODUCTION OF MISSOURI IN 1912 AND 1913.*

Commodity.	1912.	1913.
Lead ore	$11,948,358	$11,444,935
Zinc ore	12,988,803	9,664,423
Coal	7,633,864	7,468,308
Clay products *a*	6,409,346	6,598,664
Cement	3,700,776	4,556,822
Limestone	2,373,725	2,486,020
Mineral paints	2,160,718	2,359,592
Sand and gravel	1,083,704	1,109,233
Lime	721,896	734,009
Clay	562,306	470,277
Chats	408,510	304,333
Barytes	117,035	117,638
Copper	72,720	89,312
Mineral waters	81,114	84,316
Tripoli	75.565	83.995
Iron ore	92,996	83,628
Granite	98,776	42,484
Silver	21,794	21,514
Sandstone	15,004	10,195
Natural gas	11,576	6,795
Pottery	3,515	3,412
Miscellaneous *b*	5,825	20,679
Total	$50,587,926	$47,760,584

a Not including Pottery.
b Includes Petroleum and Pyrite.
* Statistics have been collected in co-operation with the United States Geological Survey excepting those for coal, lead, and zinc, which were compiled by the Federal Bureau.

ASPHALTIC ROCK.

Asphalt, bitumen, or mineral pitch occurs impregnating the sandstones in southwest Missouri. It is quarried and used locally for flagging near Liberal, Barton County.

None of the impregnated rock analyzed would warrant extraction for the bituminous content but much of it would make excellent road material and recent developments indicate that some of the deposits will be used for such in the near future.

BARYTES.

The production of crude barytes in Missouri in 1913 was 31,131 short tons valued at $117,638; in 1912, 24,530 short tons valued at $117,035.

The following table shows the production, total value, and average price per ton of crude barytes mined in Missouri from 1911 to 1913 inclusive:

PRODUCTION OF CRUDE BARYTES IN MISSOURI, 1911–1913, BY COUNTIES, IN SHORT TONS.

County.	1911.		1912.		1913.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Cole	2,581	$10,324	3,325	$13,941	1,740	$7,170
Franklin						
Jefferson			572	2,317	1,857	7,610
Miller	3,150	11,032				
Morgan			310	983	760	2,800
St. Francois			0	0	2,225	5,316
Washington	15,819	61,412	20,323	99,794	24,549	94,742
Total	21,550	$82,768	24,530	$117,035	31,131	$117,638
Average price per ton		$3.84		$4.77		$3.78

Comparison of the figures for the three years shows:
13.8% increase in production from 1911 to 1912,
41.4% " " value " 1911 to 1912,
26.9% " " production from 1912 to 1913,
0.5% " " value " 1912 to 1913.

The high price commanded by crude barytes in 1912 ($4.77) compared with the normal price obtained in 1913 ($3.78) is responsible for the variance between the percentage increase in production and comparative increase in value.

Washington County produced 73.4%, 82.8%, and 78.9%, respectively of the total State tonnage during 1911 to 1913 inclusive. During these years Missouri produced 55.8%, 65.4%, and 68.7% respectively, of the total United States production, from which it may be seen that this State is not only the largest producer of barytes but is also consistently increasing the supremacy.

Much of the crude barytes is ground and refined, the total output for 1913 being 28,689 tons valued at $426,287. The total tonnage of refined barytes sold in the United States in 1913 was 37,033. Missouri therefore produced 77.47% of the refined material. In refining the mineral it is first ground and then leached with acid to remove iron stain. The treatment adds $10 (approximately) to the cost per ton. Of the six refining mills in the United States, three are located in this State, viz.: Nulsen, Klein and Krausse and J. C. Finck Mine and Milling Company in St. Louis, and the Point Milling and Manufacturing Company at Mineral Point.

The crude mineral is found chiefly in the surface clay and is mined by means of shallow shafts and hoisted by hand windlasses. In Franklin County it occurs in fissures associated with lead. The Wrisberg mine near St. Clair is mining a fissure of this character. The ore from Miller, Morgan, Cole, and Moniteau counties, has the same general characteristics as that produced in southeast Missouri.

Cement (Portland).

During 1913, five plants operating in Missouri shipped 4,485,820 barrels of Portland cement valued at $4,556,822 or $1.016 per barrel. The same plants shipped 4,614,547 barrels valued at $3,700,776 or $0.802 per barrel during 1912 and the previous year, 1911, four plants shipped 4,114,859 barrels valued at $3,349,312 or $0.815 per barrel.

The year 1912 shows an increase in value of 10.45% over 1911, and 1913 an increase of 23.13% over 1912.

At the close of 1912 the producing plants had 456,843 barrels on hand as stock and on December 31, 1913 stock was 855,272 barrels, showing that although shipments during 1913 decreased slightly, the production was increased.

Since 1912 the plant of the Cape Girardeau Portland Cement Company at Cape Girardeau has been added to the producing list, which includes the following: Atlas Portland Cement Company, Ilasco, Ralls County; St. Louis Portland Cement Company, Cement City, Jackson County; St. Louis Portland Cement Company and Continental Portland Cement Company, St. Louis County.

The widespread occurrence of materials suitable for the manufacture of Portland cement is indicated by the location of the plants in the western, northeastern, eastern, and southeastern parts of the State.

A detailed description of the various formations of the State from which Portland cement may be manufactured is given in volume 6, second series of the reports of this Bureau.

Clay and Clay Products.

The importance of the clay-working industries can not be better emphasized than by the rank this State holds when compared with the total output of the country. In 1913 Missouri stood seventh in total production, second in the value of the output of fire brick and enameled brick, third in the value of fancy brick and of sewer pipe, fifth in front brick, sixth in value of architectural terra cotta, and tenth in the production and value of vitrified paving brick.

The following table shows the value of the brick and tile products of Missouri for the years noted:

Brick and Tile Products 1911, 1912 and 1913.

	1911.	1912.	1913.
Common brick	$1,309,164	$1,243,070	$1,270,581
Front brick	330,332	264,375	414,778
Vitrified paving brick	488,299	342,930	275,164
Ornamental brick	24,269	19,838	18,734
Drain tile	164,393	141,297	130,661
Sewer pipe	1,156,626	1,178,482	1,213,889
Terra cotta	a	654,163	480,372
Fireproofing	123,499	75,551	104,073
Fire brick	1,763,548	1,941,347	2,138,368
Miscellaneous b	909,015	548,293	552,044
Total	$6,269,145	$6,409,346	$6,598,664

b Includes silica brick, enameled brick, tile (not drain), stove lining, chimney tops, etc.
a Included under miscellaneous.

As shown by the above table, fire brick constitutes the product of chief value, amounting to more than 32% of the total in 1913. St. Louis City and County constitute the chief center of production although large plants are located at Fulton, Vandalia, and Mexico, in northeast Missouri. Sewer pipe and common brick were practically the same in value in 1913. Sewer pipe are manufactured chiefly in St. Louis and at Brownington, Henry County. The plant of the W. S. Dickey Company at the latter place is one of the largest in the country.

In addition to the manufactured products the amount of clay mined and sold by producers who do not manufacture, amounts to approximately one-half million dollars annually. The following table indicates the character and value of this material from 1911 to 1913 inclusive:

PRODUCTION OF CLAY 1911 TO 1913.

	1911		1912		1913	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Kaolin	$139	$1,270	$740	$3,874	$304	$1,957
Fire clay	215,468	498,179	287,925	552,514	235,606	465,900
Miscellaneous a	12,084	12,639	7,036	5,918	2,122	2,420
Total	$227,691	$512,088	$295,701	$562,306	$238,032	$470,277

a Includes slip clay, stoneware clay, and brick clay.

By far the largest item is flint clay which occurs chiefly in pockets in the central and northern Ozark region. This clay is non-plastic but very fine and has a high melting point. It is usually mixed with plastic fire clay in order to give it sufficient bond to work well.

COAL.

The production of coal in both 1912 and 1913 was greater than in any former year, surpassing even that of 1907 by an average of over 350,000 tons. However, the production for 1913 showed a decrease from 1912 of 21,731 tons, or 0.5 per cent, in quantity, and of $165,566, or 2.2 per cent, in value.

The following table shows the output and value during 1912 and 1913 by counties:

County.	1912.		1913.	
	Quantity. (short tons.	Value.	Quantity. (short tons)	Value.
Adair	$593,667	$965,880	$439,891	$699,244
Audrain	25,512	56,683	10,606	21,842
Barton	382,082	598,399	495,328	796,902
Bates	159,229	277,225	168,469	264,857
Boone	19,696	39,016	15,791	30,563
Callaway	22,962	56,504	32,889	69,907
Dade	6,100	11,825	5,750	9,762
Henry	143,584	260,396	261,196	437,194
Lafayette	749,598	1,454,965	729,606	1,347,090
Linn	125,649	287,504	117,625	276,455
Macon	818,170	1,251,755	778,264	1,255,417
Putnam	31,710	54,828	21,835	45,409
Randolph	483,903	781,919	481,882	769,802
Ray	375,164	723,981	343,285	651,227
Other counties*	304,015	607,601	328,631	613,528
Small mines	98,815	205,383	86,977	179,019
Total	$4,339,856	$7,633,864	$4,318,125	$7,468,308

*Caldwell, Clay, Cole, Grundy, Harrison, Howard, Johnson, Moniteau, Montgomery, Platte, Ralls, Schuyler, Sullivan, Vernon, and in addition Cass and Livingston in 1907 and Cooper in 1913.

Macon County, which was surpassed in production and value in 1911 by Lafayette County, again assumed first place in 1912 and 1913, though in value Lafayette's production still retained first rank over that of Macon. No coal is hoisted in Platte County, the production being raised through shafts in Leavenworth, Kansas, although the face of the mine is in Missouri.

The coal beds mined in Missouri in general range in thickness from 16 to 82 inches, although beds as low as 12 inches have been stripped and coal pockets in Morgan and other counties on the northern slope of the Ozarks have been worked, where they show a thickness of from 50 to 80 feet. These pockets, however, are commonly more or less distant from railroad transportation and are largely cannel coal running high in ash.

The Lexington coal bed in the Lexington field, which varies from 16 to 26 inches averaging less than 20 inches, produced over one-fourth of the State total. When the production of the Lexington bed in the Mendota field, where the bed is about 40 inches thick, is added the yield of the Lexington is about 30 per cent of the total. The Marceline field, in which the coal mined is about 29 inches thick, produced nearly 3 per cent of the whole. The Mulberry and Lower Rich Hill beds, between 3 and 3½ feet thick yielded about 16 per cent of the State total, while the Bevier bed, commonly ranging between 3 and 5 feet thick, yielded the major portion of the remaining 48 per cent. Other beds of the same or less thickness in scattered fields probably produced another 3 per cent.

The following table shows the number and percent of mines operating in beds of a given thickness and their proportion of production:

Thickness of bed in inches.		Number of mines.	Per cent of mines.	Production.	
From.	To.			(Short tons)	Per cent.
12	18	9	4.1		
18	24	43	19.6	1,500,000	36.0
44	30	45	20.5		
30	36	21	9.6		
36	42	29	13.2		
12	48	23	10.7		
48	54	30	13.7	2,800,000	62.0
54	60	11	5.0		
60		8	3.6		
Total		218	100.0	4,300,000	100.0

As shown by this table over one-third of Missouri's coal production is from beds less than 30 inches thick, and as previously stated over a quarter of the production is from a bed commonly less than 20 inches thick. So far as known Missouri produces more coal from thin beds than any other State in the Union. In the eastern States some coal is mined from thin beds, but chiefly in conjunction with those having greater thickness. The Nodaway coal bed, from 14 to 18 inches thick, has been mined in Nodaway County, and is mined at present in Iowa, just north of the Missouri line.

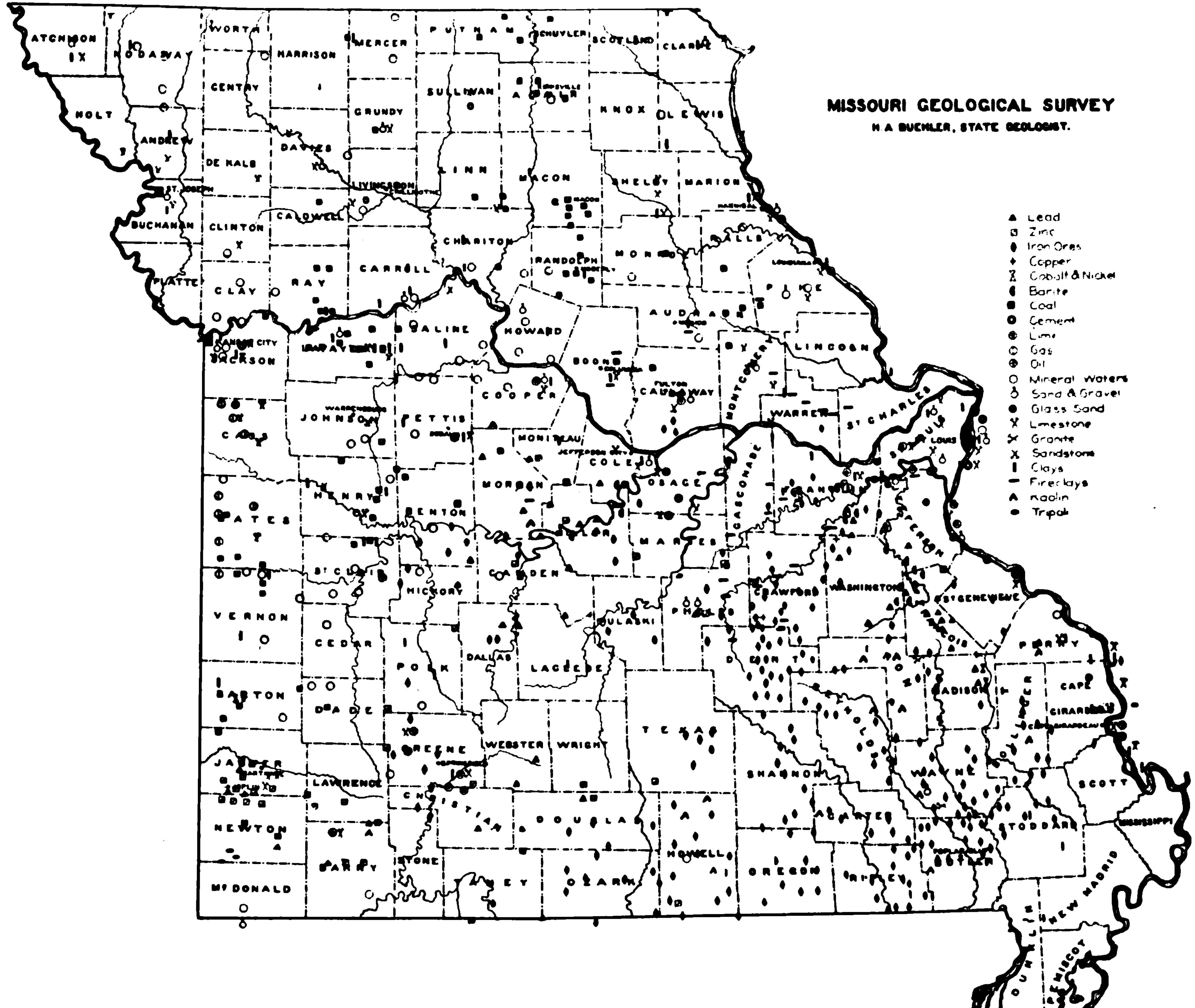
There remains in Missouri much coal in beds less than 24 inches thick and as these commonly have a good roof which permits long wall work and the use of machines, the importance of such beds may be realized. Some of the deepest shafts in the Missouri Valley have been sunk to thin beds, that at Leavenworth, Kansas, operating in a bed 22 inches thick and that at Hamilton, Mo., in a bed 18 to 20 inches thick.

The report on "The Coal Deposits of Missouri" issued by this Bureau discusses in detail the distribution, depth, thickness, roof and floor of the coal beds in every county in the State in which they occur.

Cobalt and Nickel.

No production of cobalt and nickel has been reported since the closing of the mine of the North American Lead Company near Fredericktown. The ore obtained at this property consists of a mixture of the sulphides of copper, cobalt, nickel, lead and iron, requiring a complex plant for its complete reduction.

A similar association of sulphides is found in the Flat River district in drilling for lead. In no case have these deposits shown sufficiently high percentages or been of sufficient extent to warrant exploitation. The mixture of sulphides other than lead is separated on tables in milling the lead ore mined in St. Francois County, and to some extent this is saved as a marketable product. Neither cobalt nor nickel are known to occur in this State outside the disseminated lead and zinc district of Southeast Missouri. This is probably due to the fact that extensive prospecting has not been carried on long in that district, although the same geological features occur over most of the region embraced by the St. Francois Mountains.


MISSOURI GEOLOGICAL SURVEY
H. A. BUEHLER, STATE GEOLOGIST.
Lead
Zinc
Iron Ores
Copper
Cobalt & Nickel
Barite
Coal
Cement
Lime
Gas
Oil
Mineral Waters
Sand & Gravel
Glass Sand
Limestone
Granite
Sandstone
Clays
Fireclays
Kaolin
Tripoli
ATCHISON
NODAWAY
WORTH
HARRISON
MERCER
PUTNAM
SCHUYLER
SCOTLAND
CLARK
HOLT
ANDREW
GENTRY
GRUNDY
SULLIVAN
KNOX
LEWIS
DE KALB
DAVIESS
LINN
MACON
SHELBY
MARION
BUCHANAN
CLINTON
CALDWELL
LIVINGSTON
CHARITON
RANDOLPH
MONROE
RALLS
PIKE
PLATTE
CLAY
RAY
CARROLL
AUDRAIN
LINCOLN
KANSAS CITY
JACKSON
LAFAYETTE
SALINE
HOWARD
BOONE
CALLAWAY
MONTGOMERY
WARREN
ST CHARLES
ST LOUIS
CASS
JOHNSON
PETTIS
COOPER
MONITEAU
COLE
OSAGE
GASCONADE
FRANKLIN
JEFFERSON
BATES
HENRY
BENTON
MORGAN
MILLER
MARIES
CRAWFORD
WASHINGTON
STE GENEVIEVE
VERNON
ST CLAIR
HICKORY
CAMDEN
PULASKI
PHELPS
DENT
IRON
ST FRANCOIS
PERRY
CEDAR
POLK
DALLAS
LACLEDE
MADISON
CAPE GIRARDEAU
BARTON
DADE
GREENE
WEBSTER
WRIGHT
TEXAS
SHANNON
REYNOLDS
WAYNE
BOLLINGER
SCOTT
JASPER
LAWRENCE
CHRISTIAN
DOUGLAS
CARTER
STODDARD
MISSISSIPPI
NEWTON
BARRY
STONE
TANEY
OZARK
HOWELL
OREGON
RIPLEY
BUTLER
NEW MADRID
McDONALD
DUNKLIN
PEMISCOT

COPPER.

The production of copper in Missouri in 1912 was 440,725 pounds, valued at $72,719 and in 1913, was 576,204 pounds valued at $89,312, an increase of $17,407 over 1912 and $9,261 over the largest previous production in 1911.

Previous to 1913 the entire output was obtained from concentrates recovered in milling the lead ore mined in St. Francois County. In 1913 there was an increased yield of copper from lead concentrates and the Cornwall Copper Mining & Smelting Company of Ste. Genevieve County produced a considerable quantity. This property was active during the year but has since been closed. During the past year the Swansee property has also been reopened and some ore shipped. These are the only deposits that have been operated in Missouri during recent years solely for copper.

The Copper Mountain Copper Company has placed a steam shovel on its property near Sullivan, and has started a cut along the east side of its property, for the purpose of prospecting and developing the ore bodies at that mine. The small copper furnace at this property has not been in blast during the past two years.

IRON ORES.

There has been practically no change in the iron smelting situation since the closing of the St. Louis Blast Company's furnace several years ago. The Sligo Furnace at Sligo, Mo., is in blast, the ore being obtained chiefly from the surrounding area. Some brown ore is shipped from West Plains, but this is the only property operated outside of the central district. With the present cost of transportation there is no possibility of shipping the brown ores of the southeastern part of the State. A small charcoal furnace in the region, or the reopening of a furnace in St. Louis would warrant operation in many of the pits from which ore was formerly mined.

The output in 1912 was 42,120 tons valued at $92,996 and 37,134 tons valued at $83,628 in 1913.

LEAD AND ZINC.

Approximately one-half of the value of the mineral output of the State is derived from the sale of lead and zinc ores, the production of which is derived largely from Jasper, Newton, Lawrence

and Greene Counties in Southwest Missouri, and from Washington, St. Francois, and Madison Counties in the southeastern part of the State. Although sporadic occurrences of both ores are found throughout the Ozark Plateau, very little production is reported, the only consistently producing area being the Wetherall district of Ozark County.

The following table indicates the total tonage and value for the years 1912 and 1913.

Ore.	1912.		1913.	
	Tons. Concentrates.	Value.	Tons. Concentrates.	Value.
Lead...........	$256,838	$11,948,358	$255,723	$11,444,935
Zinc............	267,158	12,988,803	247,381	9,664,423
	523,996	$24,937,161	503,104	$21,109,358

The total value for 1912 was the highest yet recorded in this State, and the output of zinc ore, due to high prices, was valued at over a million dollars more than the production of lead ore, usually the excess in value is reversed. More than four-fifths of the total production of lead is obtained from the disseminated district of Southeast Missouri. This district does not produce ores of zinc. Both lead and zinc are obtained in the Southwest district, although the former constitutes only about one-sixth of the total output.

The following tables compiled by Mr. J. P. Dunlop of the United States Geological Survey indicates the total tonnage and value, the southwest region being given by districts.

PRODUCTION OF LEAD AND ZINC IN MISSOURI IN 1912, BY DISTRICTS, IN SHORT TONS.

District.	Lead concentrates.				Zinc concentrates.			
	Galena.		Carbonate.		Sphalerite.		Silicate and Carbonate.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Southwest Missouri:								
Alba-Neck City	816	$45,562			17,966	$912,087	66	$1,246
Ash Grove-Everton	80	4,015					158	3,996
Aurora	49	2,271	19	$847	913	39,292	1,965	51,109
Carl Junction	120	6,712			7,457	392,952		
Carthage	51	2,648			3,239	150,408	28	852
Cave Springs	384	21,454			5,979	316,724		
Duenweg-Porto Rico	2,747	151,985	35	1,241	21,728	1,087,730	1,325	37,707
Granby	306	16,475	66	2,624	3,109	143,903	9,913	321,877
Joplin	4,689	252,085	19	653	43,032	2,151,198	2,520	71,592
Oronogo	1,719	91,649			11,015	510,904		
Pioneer and McDowell					152	7,604		
Sarcoxie-Reeds					342	19,328	255	7,490
Sherwood-Thom Station	952	51,953			17,226	857,883		
Spring City-Beef Branch	766	42,005	153	4,629	2,354	93,164	3,146	86,207
Springfield	227	13,421			1,777	106,900		
Spurgeon	580	30,257	69	2,829	593	29,734	33	784
Stotts City	8	440			250	12,624		
Webb City-Carterville-Prosperity	24,115	1,349,251			101,618	5,172,467	39	1,063
Wentworth					1,480	75,575	376	11,098
Zincite and Klondike	65	3,498			4,716	265,144		
Wetherill							1,297	25,840
	37,674	2,085,681	361	12,823	244,946	12,345,630	21,121	620,861
Central and Southeast Missouri	218,803	9,849,854			40	1,292	1,051	21,020
State total: 1912	256,477	11,935,535	361	12,823	244,986	12,346,922	22,172	641,881

MINE PRODUCTION OF LEAD AND ZINC IN MISSOURI IN 1913, BY DISTRICTS, IN SHORT TONS.

District.	Lead concentrates.				Zinc concentrates.			
	Galena.		Carbonate.		Sphalerite.		Silicate and carbonate.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Southwestern Missouri								
Alba-Neck City	363	$19,564	....	....	16,425	$700,741	116	$1,656
Ash Grove-Everton	15	750	....	....	....	....	75	1,125
Aurora	56	2,516	13	$381	331	12,332	2,139	46,608
Carl Junction	173	8,895	....	....	10,607	440,560	....	....
Carthage	15	809	....	....	2,391	100,727	52	947
Cave Springs	181	9,218	....	....	3,331	144,810	....	....
Duenweg-Porto Rico	4,051	202,938	4	123	20,075	824,867	1,991	37,693
Granby	388	19,519	168	5,608	3,234	122,996	10,708	269,133
Joplin	3,963	212,005	106	3,488	42,061	1,775,228	1,457	26,651
Oronogo	1,449	74,069	....	....	12,023	478,154	....	....
Sarcoxie-Reeds	....	....	....	....	1,719	71,451	490	10,000
Sherwood-Thom Station	1,432	75,480	....	....	21,700	774,180	....	....
Spring City-Beef Branch	1,839	88,597	32	948	2,952	91,178	2,043	42,231
Springfield	56	3,043	....	....	650	30,000	....	....
Spurgeon	146	6,580	....	....	1,671	73,759	1	30
Webb City-Carterville-Prosperity	21,771	1,125,324	....	....	77,469	3,173,220	....	....
Wentworth and Stotts City	....	....	....	....	601	24,549	690	14,800
Zincite and Klondike	81	4,187	....	....	8,577	341,634	....	....
Wetherill and Taney	....	....	....	....	....	....	1,130	19,098
	35,979	1,853,494	323	10,548	225,817	9,180,386	20,892	469,972
Central and Southeastern Missouri	219,511	9,580,893	....	....	33	574	639	13,491
State total 1913	255,400	11,434,387	323	10,548	225,850	9,180,960	21,531	483,463

The total recoverable metallic content of the lead and zinc concentrates in 1912 was $34,780,248; in 1913 approximately $29,494,000. The smelting of the concentrates or their reduction to metal increased the mine production value $9,843,087 in 1912 and $8,384,706 in 1913, of which amount $3,987,852 and $4,053,273 was the increase due to the smelting of lead in 1912 and 1913 while the smelter increase for zinc was $5,855,235 and $4,331,433 respectively for the same periods.

The shipments of lead concentrates from the southeast and central districts in 1912 was 218,803 tons valued at $9,849,854 against 219,511 tons valued at $9,580,893 in 1913. The value per ton of concentrates was $45.01 in 1912 against $43.63 in 1913, a decrease of $1.38 although the grade increased from 67.1 per cent to 67.2 per cent in lead content.

The lead concentrates in southwest Missouri amounted to 38,035 tons valued at $2,098,504 in 1912 and 36,302 tons valued at $1,864,042 in 1913. Of this production 361 tons in 1912 and 323 tons in 1913 were lead carbonate. The average lead content of the concentrates was 79.5 per cent and 78.8 per cent and the average price per ton was $55.36 and $51.50 in 1912 and 1913 respectively.

The chief output of zinc ore is blende, the sulphide of zinc. In 1912 the production of blende ore was 244,986 tons valued at $12,346,922 and in 1913 it decreased to 225,850 tons valued at $9,180,960. Less than a hundred tons of blende concentrates were produced outside the Southwest district during the two years.

In 1912 the price per ton averaged $50.44 while in 1913 it was $40.70 a decrease in price of almost $10 per ton.

The value of zinc carbonate and silicate concentrates was $641,881 in 1912, and $483,463 in 1913, the tonnage output being 22,172 and 21,531 respectively. The value per ton was $28.95 in 1912 and $22.45 in 1913.

The total quantity of rock mined to obtain the above tonnages was 13,385,511 tons in 1912 and 12,300,100 tons in 1913.

LIME.

During 1912 the production of lime decreased slightly, $770,101 being the value of total production, but in 1913, production again increased with a total of $821,305. The following table shows the value of lime burned and the various purposes for which it was used:

Production of lime in Missouri in 1911, 1912 and 1913, by uses.

	1911.	1912.	1913.
Commercial	$438,908	$375,095	$427,333
Paper mills	....	....	19,597
Chemical works	27,024	38,157	52,917
Hydrate	66,336	57,987	87,296
Miscellaneous a	256,631	298,862	234,180
	$788,988	$770,101	$821,305

a Includes alkali works, agricultural purposes, sugar factories, and tanneries.

Missouri produces high calcium limes exclusively, as the various dolomitic formations are too impure to be used for this purpose. It frequently requires but a slight amount of impurities to make lime when slacked show a gray color, and although it may be strong it cannot be used for finishing purposes. This is the case with the lime burned from what is known as the Kimmswick (Trenton) limestone in the eastern part of the State. The Burlington formation usually burns to a pure white lime having cool working properties, but some of the stone burns to a lime that is very "hot". The widespread occurrence of the Burlington together with good transportation facilities in both northeastern and southeastern Missouri, have favored the establishment of large plants, the most important being in the latter section.

Mineral Paints.

The production of mineral paints in Missouri is steadily increasing. In 1911, 28,201 tons were produced, valued at $2,034,339; in 1912, 20,657 tons valued at $2,160,718, an increase in value of 6.2 per cent; and in 1913, 24,278 tons valued at $2,-359,592, an increase of 9.2 per cent in value, and the largest yearly production yet reported, being 6.8 per cent of the total production of the United States.

Only those products are included in the production which are natural mineral pigments or are manufactured directly from the mineral or ores, namely: mineral primers, venetian red, whiting, red lead, white and blue sublimed lead, orange mineral, and litharge.

The white lead included is not produced by the old dutch process or any process consuming metallic lead.

Mineral Waters.

The sale of mineral waters for 1913 as reported by 34 firms was 697,467 gallons valued at $84,316, an average price of 12 cents per gallon. This was an increase of 89,082 gallons over 1912, when the output was reported as 608,385 gallons valued at $81,114.

Missouri has many mineral springs and the above sales are but a small fraction of the quantity of water really used for medical and other purposes. Local consumption or water used directly from the wells at resorts is not quoted in the above, nor is the quantity used in the manufacture of soft drinks included.

The following is a list of springs from which water was sold during 1913:

American Spring, St. Louis, St. Louis County.
B. B. Springs, Bowling Green, Pike County.
Belcher Artesian Well, St. Louis, St. Louis City.
Blue Lick Springs, Blue Lick, Saline County.
Bokert Springs, near De Soto, Jefferson County.
Carrollton Spring, Carrollton, Carroll County.
Chalybeate Springs, Paris Springs, Lawrence County.
Chouteau Springs, near Boonville, Cooper County.
Crystal Lithium Spring, Excelsior Springs, Clay County.
Cusenbary Spring, Mount Washington, Jackson County.
Excelsior Saline Spring, Excelsior Springs, Clay County.
Grand River Mineral Spring, near Mercer, Mercer County.
Haymaker Spring, Mercer County, near Lineville, Iowa.
Jackson Lithia Spring, Mount Washington, Jackson County.
Lithia No. 1 Spring, Excelsior Springs, Clay County.
Livertone Spring, Pike County.
Mee Soda Well, Excelsior Springs, Clay County.
Musick Spring, Eldorado Springs, Clay County.
Natrona Soda Spring, Excelsior Springs, Clay County.
Old Orchard Spring, Old Orchard, St. Louis County.
Peerless Spring, Excelsior Springs, Clay County.
Regent, Siloam, Soterian, and Sulpho-Saline Springs, Excelisor Springs, Clay County.
Salax Spring, Excelsior Springs, Clay County.
Salt Sulphur Well, Excelsior Springs, Clay County.
Soda Saline spring, Excelsior Springs, Clay County.
Sweet Springs, Sweet Springs, Saline County.
Valle Springs, Independence, Jackson County.
White Springs, Independence, Jackson County.
Windsor Spring, Windsor, Henry County.
Wyaconda and La Grange Springs, La Grange, Lewis County.

Nickel (See Cobalt and Nickel).

Petroleum and Natural Gas.

No production of petroleum was reported in 1912, following an output reported in excess of $5,000.00 for the previous year, but in 1913 one producer reported a small output. Many of the shallow wells in the western part of the State encounter showings

of oil in the Pennsylvanian formations. In no case, however, have these tapped any considerable reservoirs. While there is practically no production of oil, an output of gas was reported from 63 wells in 1912 and from 66 wells in 1913.

The following table shows the production by counties for the past three years:

Production of natural gas in Missouri 1911 to 1913, by counties.

County.	1911.	1912.	1913.
Bates	$4,643	$5,204	$4,090
Cass	1,075	425	575
Jackson	4,778	5,947	2,130
Total	$10,496	$11,576	$6,795

The wells are all shallow, the deepest being less than 500 feet. The gas is usually consumed by the owner of the well for domestic purposes. During the past few months a number of wells have been drilled near Parkville, three of which are reported to have a daily capacity of 300,000, 600,000 and 1,000,000 feet, respectively. A pipe line is being laid to Parkville at the present time for the purpose of supplying that place with gas for domestic use. In addition to the three counties reporting above, shallow wells have encountered gas in Vernon, Barton, Bates, Johnson, Clay, Platte and Clinton counties. A majority of these were soon drowned due to lack of care in keeping out water.

Pyrite.

During 1912, but one company, the Rock Island Mining Company at Leslie, Franklin County, reported sales of pyrite. In 1913 this company reported that no pyrite was mined by them, and the principal production for the year was made chiefly by the Rolla Mining Company, near Rolla, the shipping point for the ore being Cabeen, on the St. Louis and San Francisco Railroad. The ore as mined is about 40 per cent sulphur on the dry basis and is used in the manufacture of sulphuric acid at East St. Louis, Ill.

At the present time the Rolla Mining Company is opening an extensive deposit near Morrelton, owned by Julian Pickels of that place. Drilling has shown a thickness of over 56 feet overlain by 7 feet of hematite. The deposit has a good roof and does not carry a notable quantity of water. Many of the old iron

banks of the central Ozark district carry pyrite near their base. In many cases this mineral could be mined at a profit after removing the iron ore. The deposit worked near Rolla and the ore obtained from Leslie occurred below commercial iron ore. Additional prospecting would no doubt show many of these deposits that could be opened and mined cheaply.

SAND AND GRAVEL.

The sand and gravel produced in 1913 was valued at $1,109,233; in 1912 at $1,083,704; and in 1911 at $1,042,674. These figures indicate an increase of 3.94 per cent from 1911 to 1912, and 2.36 per cent from 1912 to 1913.

The following table shows the value of the sand and gravel used for various purposes, 1911 to 1913 inclusive:

Production of sand and gravel for 1911-1913.

Purpose.	1911.	1912.	1913.
Glass sand	$ 82,705	$ 81,817	$91,284
Paving sand	15,364	16,897	69,451
Building and polishing sand	55,884	59,788	63,665
Moulding sand	49,522	71,366	63,695
Building sand	533,722	521,164	526,912
Railroad ballast			38,679
Miscellaneous a	46,214	78,761	22,716
Gravel	259,263	253,911	232,831
Total	$1,042,674	$1,083,704	$1,109,233

a Includes fire and engine sand, and others.

Much of the moulding sand and all of the glass sand is obtained from the St. Peter sandstone which occupies a narrow belt in the eastern portion of the State, extending from Callaway to Cape Giradreau counties.

The greater part of the sand and gravel used for building purposes is obtained from dredges, located along the principal rivers, especially the Mississippi and Missouri. On the Mississippi pumping plants are operated at Cape Girardeau, Crystal City, St. Louis, Louisiana, Hannibal and Canton, while along Missouri, the production is obtained from St. Charles, Jefferson City, Glasgow, Lexington, Kansas City and St. Joseph. Plants on Meramec pump an excellent grade of sand and gravel at Pacific, Drake, Sherman, and Valley Park. On Black River, plants are located at Poplar Bluff and Mill Spring. Gravel is dredged from Joachim Creek near Festus and Piney Creek supplies sand

to shipping plants at Arlington and Newburg, in Phelps County. Roofing gravel is obtained from Osage River at Osage City, and a dredge located on Salt River near New London is working a large gravel bar. In the northwest part of the State, Nodaway River furnishes sand at Maitland and Skidmore. Bank sand is produced at Commerce in Southeast Missouri. Most of the streams of the Ozark region are capable of producing an inexhaustable supply of sand and gravel.

STONE.

Missouri stands ninth among the States in the value of the output of stone products and is second only to Indiana in the production of limestone for building purposes. The importance of the cut stone industry is due entirely to the extensive quarries at Carthage, Jasper County, and Phenix, Greene County.

The following table shows the total value of the stone output in 1911 to 1913 inclusive:

Production of stone, 1911, 1912 and 1913.

	1911.	1912.	1913.
Limestone	$2,179,767	$2,373,725	$2,486,020
Granite	139,070	97,776	42,484
Sandstone	19,748	15,004	10,195
Chats (mine tailings)	225,540	408,510	304,331
Total	$2,564,125	$2,895,015	$2,843,030

LIMESTONE.

The production of limestone during 1912 and 1913, arranged according to counties, and according to uses, is shown in the following tables:

Total output of limestone by counties.

County.	1912.	1913.
Andrew	$ 67,266	$74,158
Boone	34,351	74,465
Buchanan	a	27,650
Cape Girardeau	75,739	110,879
Cass	815	1,610
Clay	120,500	214,480
Clinton	a	4,186
Cole	26,176	28,205
Cooper	63,697	66,082
Daviess	8,234	a
Franklin	5,462	6,818

	1912.	1913.
Greene	99,334	79,701
Grundy	a	2,81
Holt	a	1,602
Jackson	569,681	538,517
Jasper	305,450	258,955
Lafayette	2,103	5,104
Marion	46,079	34,253
Monroe	5,935	7,325
Montgomery	1,999	a
Osage	888	a
Pike	11,105	12,683
Ste. Genevieve	21,983	67,580
St. Louis	150,604	136,439
St. Louis City	516,160	394,795
Other counties	240,015	337,705
Total	$2,373,725	$2,486,020

a Included in other counties.

Production of limestone 1912 and 1913, according to uses.

	1912.	1913.
Building purposes (rough)	$138,516	$110,080
Building purposes (sawed or cut)	310,277	268,970
Paving	26,251	14,596
Curbing	6,170	9,269
Flagging	a	3,328
Rubble	204,400	127,683
Riprap	290,223	473,399
Crushed (road-making)	262,114	338,849
Crushed (railroad ballast)	383,190	405,665
Crushed (concrete)	644,121	623,436
Blast furnace flux	38,737	35,874
Glass factories	27,682	25,824
Sugar factories	a	3,992
Alkali works	a	
Agricultural purposes	7,567	8,297
Miscellaneous	33,719	36,731
	$2,373,725	$2,486,020

a Included in miscellaneous.

According to the above tables, Jackson County and St. Louis City and County are the largest producers of limestone, the output being largely crushed rock. Crushers contribute largely to the output in Clay County, while the totals for Greene and Jasper counties are due to the cut stone industry at Carthage and Phenix.

Missouri stands sixth among the States in the production of limestone, being surpassed by Illinois, Indiana, New York, Ohio, and Pennsylvania. The output of crushed rock is continually

increasing, and this State now stands third in the production of this material for concrete, fifth for railroad ballast, and seventh for road making. Due to the location of large quarries along Mississippi and Missouri rivers, this State is the chief producer of riprap.

The fact that Missouri is the second State in the production of fine building stone indicates the extent and value of the quarrying districts at Carthage and Phenix. The Burlington limestone produced at these quarries consists of light gray, crystalline, durable stone that takes an excellent polish for interior decoration. The Burlington formation covers an extensive area in Southwest Missouri, and new quarries are now being opened at Cassville in Barry County. The stone is being shipped as far east as New Yotk and to the Pacific Coast on the West. It will be used in the construction of the new State Capitol at Jefferson City.

During the past year a new quarry has been developed along the river bluffs several miles north of Ste. Genevieve. The stone is of the oolitic Bedford type and has the same general character as that produced in Indiana. Some of the lower ledges are more crystalline and more compact in texture. The development of these quarries should add materially to the stone resources of the State, as they provide a quarry product that is able to compete in every way with the Indiana stone.

GRANITE.

There has been a decrease in the production of granite during the past two years, as indicated by the following figures: 1912, value $98,776; in 1913, $42,484. The output is chiefly restricted to the Graniteville and Synaite districts of Iron and St. Francois counties, although a small amount was shipped from Kerrigan in Wayne County during 1912.

The granitic area includes a large part of St. Francois, Madison and Iron counties, the rocks consisting chiefly of deep red granite and dark fine grained porphyry. The granite can be produced in large blocks free from flaws and this stone is the chief product of the operating quarries. The prophyry is usually badly jointed and cannot be obtained in large blocks. It does not have as striking a color as the granite and has been used in the past only for the manufacture of paving blocks.

SANDSTONE.

The output of sandstone has decreased during the last three years from a total of $39,398 in 1910 to $10,195 in 1913. The following table shows the value of the output of sandstone according to uses for 1911, 1912 and 1913.

Production of sandstone 1911, 1912 and 1913 according to uses.

	1911.	1912.	1913.
Rough for building	$2,800	$1,921	$2,070
Cut or sawed for building	9,804	4,078	2,839
Rubble	1,792	1,376	970
Riprap	4,010	4,280	b
Miscellaneous	1,342	3,350	4,316
Total	$19,748	$15,005	$10,195

a Includes paving, curbing, flagging, crushed for road-making and for concrete.
b Included in miscellaneous.

The more extensive use of concrete each year for structural purposes has decreased the demand for rubble stone for use in foundations, bridge piers and house construction. In the case of limestone the demand for crushed stone for use in concrete has offset the decrease in demand for building sizes, but sandstone has suffered because of its inadaptability for use in concrete where limestone or chats is easily obtainable. This is perhaps the chief cause for the steady decline in the production of sandstone.

Johnson and Callaway counties are the chief producing areas.

CHATS.

The tailings produced in milling the lead and zinc ores of Southeast and Southwest Missouri are used for railroad ballast, road construction and concrete.

The following table shows the total tonnage used during the past three years and the amount shipped from each mining district.

PRODUCTION OF CHATS ACCORDING TO USES FOR 1911 AND 1912.

Use.	1911.		1912.		1913.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Southeast Missouri.						
Railroad purposes	214,270		462,498		431.565	
Commercial purposes	273,544		258,623		88,417	
Total	487,814	$73,172	721,121	$108,168	519,982	$77,997
Southwest Missouri.						
Railroad purposes	650,741		1,449,207		799,440	
Commercial purposes	365,048		553,075		709,467	
Total	1,015,789	$152,368	2,002,282	$300,342	1,508,907	$226,336
State total	1,503,603	$225,540	2,723,403	$408,510	2,028,889	$304,333

An arbitrary figure of 15 cents per ton has been used in computing the value in the above table. Millions of tons are produced each year, the disposal of which is a matter of considerable expense to the mining companys. The chats of the Southwest district consist largely of limestone and flint and that of Southeast, magnesian limestone or dolomite. Either material makes a fair road metal, is excellent as a railroad ballast, and is used extensively in concrete work.

SILVER.

The lead concentrates of Southeast Missouri run about one ounce of silver per ton. When an exceptionally pure lead is desired, this silver is recovered in the refining process. During 1913 a small quantity of silver was obtained from the oxidized copper ores shipped from the Cornwall copper mine in Ste. Genevieve County. This, however, did not materially increase the value of the output over 1912, the value being $21,794 for that year against 21,514 for 1913.

TRIPOLI.

Tripoli is quarried chiefly in Newton County, near Seneca and Racine, the output being valued at $75,565 in 1912 and $83,995 in 1913. Each year there has been a slight increase in the value of the product, the production in 1910 being $71,978. Almost the entire output is used for filters, the porous nature rendering it exceptionally valuable for this purpose. Its porosity causes it to absorb water or other liquids readily by capillary attraction. This property has recently been utilized in connection with electric fans, the tripoli being saturated with deodorizers, germicides or water, the strong current of air playing upon the stone causes rapid evaporation with a corresponding lowering of temperature and circulation of the disenfectant.

ZINC.

(See Lead and Zinc.)

LAWS GOVERNING THE BUREAU OF GEOLOGY AND MINES.

Sec. 6632. Bureau of geology and mines established.—There is hereby created and established a bureau of "geology and mines" for the State of Missouri, which shall be under the direction and in charge of a board of managers, which shall consist of the governor, who shall be *ex officio* president of the board, and four citizens from the state at large, who shall be appointed by the governor, by and with the consent of the senate, and shall hold their term of office four years.

Sec. 6633. State geologist—qualifications—how appointed—headquarters.—The board of managers are authorized, as soon as they are organized, to appoint one state geologist, who shall be a person of competent scientific and practical knowledge of the sciences of geology and mineralogy, and whose headquarters shall be located at the state school of mines at Rolla, who shall be the director of the survey, and said state geologist may appoint such assistants and subordinate assistants and laborers as may be deemed necessary in order to make a thorough scientific, geological and mineralogical survey of the state.

Sec. 6634. Property to be kept at school of mines at Rolla.—The board of managers of the bureau of geology and mines are hereby authorized and directed to transfer all instruments, books, charts, cabinet collections and other property of the State of Missouri now under control of said board to the state school of mines at Rolla and to establish the headquarters of the geological survey at said state school of mines.

Sec: 6635. Duty of state geologist and assistants.—It shall be the duty of the state geologist and his assistants, under the instructions and directions of the board of managers, to carry on, with as much expedition and dispatch as may be consistent with minuteness and accuracy, a thorough geological and mineralogical survey of the state already begun, with a view to determine the order, succession, arrangement, relative position, dip or inclination and comparative magnitude of the several strata or geological formations within this state, and to discover and examine all beds or deposits of mineral contents and fossils, and to

determine the various positions, formations, and arrangement of the many different ores, clays, rocks, coals, mineral oils, natural gas, mineral and artesian waters and other mineral substances as may be useful or valuable; also, to note carefully the character of the soils and their capacities for agricultural purposes, the growth of timber and other scientific matters that may be of practical importance and interest; and said geologists shall cause to be represented on the map of the state, by colors and other appropriate means, the various areas occupied by the different geological formations in the state, and to mark thereon the localities of the respective beds or deposits of the various mineral substances, and, on the completion of the survey, to complete a memoir of the geology and mineralogy of the state, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey.

Sec. 6636. State geologist to inspect lands.—On the presention of a petition to the state geologist signed by not less than fifty freeholders who reside in the neighborhood of lands situated in any county in this state which they may believe to contain or in which have been found valuable ore, clays, rocks, coals, mineral oils, or mineral matter, said petition being certified by the clerk of the county court in which the petitioners reside to contain the names of fifty freeholders residing within the neighborhoods of the lands, which lands shall be described in the petition according to government surveys, it shall be the duty of the state geologist in person or by assistants as soon as practicable to examine and inspect said lands and make report and map as to existence on said lands of valuable ores, clays, coals, mineral oils, or mineral matter found, and embody the same in his report now directed to be made by section 6635, Revised Statutes of Missouri, 1909.

Sec. 6637. Shall make maps, publish reports, etc.—It shall be the duty of the state geologist to make or cause to be made detailed maps and reports of counties or districts as fast as completed, which maps shall embrace all such geological, mineralogical and scientific details necessary to make complete reports of said districts or counties. The state geologist may also, from time to time, publish or cause to be published any reports of work completed, in the form of pamphlets or bulletins for general distribution.

Sec. 6638. Geologist to form a cabinet collection, etc.—It shall be the duty of the state geologist to collect full suits of all

materials, rocks, ores, fossils or other mineral substances of scientific or practical interest or utility as may be discovered, and that may be necessary to form a complete cabinet collection, to illustrate the various resources of the state, as may be necessary to assist in preparing the various reports of the survey.

Sec. 6639. Duty of assistants.—It shall be the duty of the said assistants to make full and complete examinations, assays and analyses of all such rocks, ores, soils or other substances as may be submitted to them by the state geologist for such purpose, and to furnish him with a detailed and complete account of the results so obtained.

Sec. 6640. Geologist may furnish items of information, etc. —The state geologist, from time to time, may furnish items of general information or new discoveries for publication in newspapers: *Provided*, the preparation of the manuscript and publication thereof does not interfere with the progress or add to the expense of the survey; he may also have authority to furnish cabinets for colleges or public museums, located within the State of Missouri, of minerals, rocks or fossils: *Provided*, said institutions shall pay the expense of preparing, labeling, transporting and putting up said collection, and also, further, that in the selection of said specimens the general state collection is not deprived of duplicates of the same, and that the state collection is not seriously injured.

Sec. 6641. Board to determine place for cabinet.—The board, with the state geologist, may determine the place for the state cabinet and headquarters of the survey.

Sec. 6642. Board to report to general assembly, etc.—It shall be the duty of the board of managers to report to each general assembly the progress and codnition of the survey, an accurate account of money spent, and such reports of the state geologist and his assistants as have been completed, together with all such information as may be deemed necessary and useful.

Sec. 6643. Power of the board, etc.—The board shall have power to take possession of all property of former surveys, whether reports, maps, collections, instruments or other property belonging to the state, and all persons now in possession of the same shall deliver them up to the order of the president of the board of managers: *Provided*, that no cabinet or library already arranged shall be removed, but the state geologist and his assistants shall have the power at any time to examine or study such collections in preparing their reports.

Sec. 6644. Board to make by-laws, etc.—The board may make such by-laws and regulations for the government and control of its meetings and labors of the state geologist and his assistants as may be deemed necessary.

Sec. 6645. Compensation of the board—salaries of geoogists.—As full compensation for the members of the board of managers, they shall be allowed their necessary expenses while attending to the duties assigned them by this chapter. The board shall fix the salary of the state geologist, not to exceed three thousand dollars per annum, and his chief assistant, which shall not exceed one thousand eight hundred dollars per annum; for the principal assistant or paleontologist, if one is employed, not over one thousand eight hundred dollars.

Sec. 6646. State geologist may appoint other assistants, etc.—The state geologist may, with the approval of the board, appoint other necessary assistants, whose pay shall not exceed five dollars per day, and such other necessary laborers or assistants as may be necessary, who shall receive a fair compensation for their work. He shall also have power to negotiate for such chemical work, chemical apparatus and chemicals as may be necessary, and may, from time to time, with the approval of the board, have such work done. He may also, with the approval of the board, employ special assistants in paleontology, provided it be deemed necessary.

Sec. 6647. Accounts of salaries and expenses, how made.—All accounts of salaries and expenses shall be made under oath. and certified by the board, and filed with the auditor of the state.

Sec. 6648. Board to have general management of survey. etc.—The board of managers shall have the general management of the survey, and have full power to remove the state geologist and appoint his successor, when deemed necessary for the good of the work entrusted to him; and the state geologist shall have full control over his assistants, and have power to remove them when deemed necessary.

Sec. 6649. State geologist and assistants shall take oath of office, etc.—The board of managers, the state geologist and each of his principal assistants shall, before entering upon the discharge of their duties, take the usual oath of office to faithfully perform all the services required of them under this chapter, and to abstain from all pecuniary speculations for themselves or others in the objects of their survey during its progress.

Sec. 6650. State auditor to draw warrant for salaries, ex-

penses, etc.—The president of the board shall, from time to time, certify to the state auditor the sums of money required to pay the salaries of the state geologist and his assistants and the incidental expenses of the bureau; and on receiving such certificates, the auditor of the state shall draw his warrant on the treasurer of the state for the requisite amount in favor of the parties and persons entitled to receive the same, and shall charge the several sums so paid to the account of the proper appropriation.

PUBLICATIONS OF THE BUREAU OF GEOLOGY AND MINES.

The following is a complete list of the publications issued by the present Bureau of Geology and Mines and former Geological Surveys. The reports of the second series are given first, since these are still available for distribution. A majority of those listed under the heading of Former Surveys are exhausted, The volumes available are distributed free upon receipt of transportation charges.

By a recent postal ruling, books may be sent by parcel post, by knowing the weight of the volume given in this list the exact postage can therefore be determined at any post office. The Biennial Reports are sent at a uniform charge of 10 cents. All publications sent to foreign countries, go at the rate of two ounces for one cent.

The reports may be obtained upon application to H. A. Buehler, State Geologist, Rolla Missouri.

Vol. No. 2nd series.		Weight. (ounces)
I.	Geology of Miller County, by E. R. Buckley, A. F. Smith and S. H. Ball, xvi + 207 pp., XVIII pls., including geologic map, 56 figs. 1913............	33
	Describes the topography, general geology, and mineral resources of Miller County, Mo.	
II.	The Quarrying Industry of Missouri, by E. R. Buckley and H. A. Buehler, xv + 371 pp., LIX pls., including geologic map of Missouri. 1904..........	56
	Discusses properties, geology, distribution and laboratory tests of Missouri granites, rhyolites, limestones and sandstones and describes the quarries from which they are obtained.	
III.	The Geology of Moniteau County, by F. B. Van Horn, ix + 104 pp., XIII pls., including geologic map, 25 figs. 1905..................................	24
	Describes the topography, general geology and mineral resources of Moniteau County, Mo.	
IV.	Geology of the Granby Area, by E. R. Buckley and H. A. Buehler, viii + 120 pp., XLII pls., including general geologic, topographic and outcrop map, 3 figs. 1906...	34
	Describes the general geology, occurrence of lead and zinc ores of the Granby Area in Newton County, Mo., and discusses the gensis of the ores of southwestern Missouri.	
V.	Public Roads, their improvement and maintenance, by E. R. Buckley, xiii + 124 pp., XXX pls. 1907..	29
	Contains specifications for building roads, directions for their construction, improvement and upkeep, a chapter on road materials, etc.	
VI.	The Lime and Cement Resources of Missouri, by H. A. Buehler, xvi + 255 pp., XXXVI pls., including a geologic map of Missouri, showing location of lime and cement plants. 1907................................	45
	Discusses properties, manufacture and production of lime and cement, the distribution of lime and cement resources by counties, including analyses and a chapter on the geological formations of Missouri and their composition.	

VII.	The Geology of Morgan County, by C. F. Marbut, xiv + 97 pp., XIX pls., including a geologic map of Morgan County, 19 figs. 1908................ Describes the topography, general geology and mineral resources of Morgan County, Mo.	25
VIII.	The Geology of Pike County, by R. R. Rowley, xiv + 122 pp., XX pls., 13 figs., geologic map of Pike County, 1908.............................. Describes the topography, general geology, mineral resources and paleontology of Pike County, Mo.	27
IX.	Geology of the Disseminated Lead Deposits of St. Francois and Washington counties, by E. R. Buckley, 2 pts.; pt. 1. xvi + 259 pp., Pls. I–XXXIX, 10 figs.; pt. 2 pls. XL–CXXI, including a general geologic map of southeastern Missouri. 1909.. Discusses location, history, production, physiography, general geological history, structure, mines, ores, genesis of the ores of southeastern Missouri, with a chapter on barite and galena in the potosi formation.	84
X.	The Iron Ores of Missouri, by G. W. Crane, xvi + 434 pp., XLVIII pls., 29 figs., and geologic map of Missouri showing the location of the iron deposits. 1912.. Discusses the history, development, production, types and distribution of Missouri iron ores and general geology and physiography of the ore-bearing district.	64
XI.	The Coal Deposits of Missouri, by Henry Hinds, xi + 503 pp., XXIII pls. 97 figs., and maps of the Clinton, Calhoun, Lexington, Bevier, Huntsville and Richmond quadrangles and geological map of Missouri, 1912.............. Describes briefly the Pennsylvanian series in Missouri and discusses in detail the mode of occurrence, coal industry, the distribution by counties, analysis, and tests of Missouri coal.	59
XII.	The Geology of the Rolla Quadrangle, by Wallace Lee, xii + 111 pp., X pls., 17 figs., topographic and geologic maps of the Rolla quadrangle, 1913...... Describes the topography, physiographic history, general geology and mineral resources of the Rolla quadrangle in Phelps and Dent counties, Mo.	23

IN PRESS.

XIII.	The Stratigraphy of the Pennsylvanian Series in Missouri, by Henry Hinds and F. C. Greene, with a chapter on Invertebrate Paleontology by G. H. Girty, 500 + pp., XXXII pls., 5 figs. To be issued early in 1915. Estimated weight..	64

BIENNIAL REPORTS.

	Postage.
Biennial Report of the State Geologist to the 42d General Assembly, by E. R. Buckley, 83 + 3 pp., VIII pls. 1903.................................. Describes work of Bureau during years 1901 and 1902.	10c
Biennial Report of the State Geologist to the 43d General Assembly, by E. R. R. Buckley, 56 pp., III pls. 1905............................ Describes work of Bureau during years 1903 and 1904.	10c
Biennial Report of the State Geologist to the 44th General Assembly, by E. R. Buckley, 57 pp. 1907.. Describes the work of Bureau during years 1905 and 1906.	10c
Biennial Report of the State Geologist to the 45th General Assembly, by H. A. Buehler, 59 pp., 1909....................................... Describes work of Bureau during years 1907 and 1908.	10c
Biennial Report of the State Geologist to the 46th General Assembly, by H. A. Buehler, 68 pp., VI pls. 1911.................................. Describes work of Bureau during years 1909 and 1910.	10c
Biennial Report of the State Geologist to the 47th General Assembly by H. A. Buehler, 54 pp., III pls. 1913.................................. Describes work of Bureau during years 1911 and 1912.	10c

FORMER SURVEYS. [a]

The following is a list of publications of this Bureau up to the publications of volume 13, 1st series. *Editions exhausted.

1.* *Report of a Geological Reconnaissance* of that part of the State of Missouri adjacent to the Osage River, made to William H. Morell, chief engineer of the State, by order of the Board of Internal Improvement, by Henry King, M. D. Geologist. (Senate Journal, Appendix, 1st Session, 11th General Assembly, pages 506–535.) Jefferson City, 1840.

[a] In this list the publications of the Survey are arranged in the order in which they were transmitted for publication.

2.* *First and Second Annual Reports* of the Geological Survey of Missouri, by G. C. Swallow, State Geologist, 448 pages, 17 plates, 18 sections, 26 figures and 5 maps, 8 vo. cloth. Jefferson City, December, 1855.

3.* *Third Report of Progress*, of the Geological Survey of Missouri, by G. C. Swallow, 3 pages, Jefferson City, December 1856.

4.* *Fourth Report of Progress*, of the Geological Survey of Missouri, by G. C. Swallow, 8 pages. Jefferson City, December, 1858.

5.* *Fifth Report of Progress*, of the Geological Survey of Missouri, by G. C. Swallow, 13 pages. Jefferson City, December, 1860.

6.* *Geological Report of the Southwestern Branch of the Pacific Railroad, State of Missouri*, by G. C. Swallow, xvii + 93 pp., 2 pls., fold map. St. Louis, 1859.

7.* *Annual Report of the State Geologist*, of the State of Missouri, by Albert D. Hager, 23 pages. Jefferson City, December, 1870.

8.* *Report of the Geological Survey* of the State of Missouri, 1855–1871, by G. C. Broadhead, F. B. Meek and B. F. Shumard, 327 pages, 29 illustrations and 9 maps, 8vo, cloth. Jefferson City, March, 1873.

9.* *Preliminary Report on the Iron Ores and Coal Fields*, from the field work of 1872, by R. Pumpelly, A. Schmidt, G. C. Broadhead and W. B. Potter, 671 pages, 190 illustrations and an atlas with 14 large sheets, 8vo, cloth. Jefferson City, April, 1873.

10.* *Report of the Geological Survey* of the State of Missouri, including field work of 1873–1874, by G. C. Broadhead, 794 pages, 91 illustrations and an atlas of 15 sheets, 8vo, cloth. Jefferson City, August, 1874.

11.* *Industrial Report on Lead, Zinc and Iron*, together with notes on Shannon county and its copper deposits, by Chas. P. Williams, Ph. D., Acting State Geologist, 199 pages and 11 illustrations, 8vo, cloth. Jefferson City, December, 1876.

12.* *Bulletin No. 1* by Arthur Winslow, G. E. Ladd, A. E. Woodward and G. Hambach, 85 pages and 2 sketch maps. Jefferson City, April, 1890.

13.* *Bulletin No. 2*. A Bibliography of the Geology of Missouri, by F. A. Samson, 76 pages, 810 titles. Jefferson City, December, 1890.

14.* *Bulletin No. 3*. By G. E. Ladd and A. E. Woodward, 101 pages, 4 plates, 3 sections and 2 sketch maps. Jefferson City, December, 1890.

15.* *Biennial Report of the State Geologist*, Transmitted to the 36th General Assembly, Arthur Winslow, State Geologist, 53 pages, 2 diagrams. Jefferson City, January, 1891.

16.* *Bulletin No. 4*. A description of some Lower Carboniferous Crinoids from Missouri, by S. A. Miller, 40 pages and 5 plates. Jefferson City, February, 1891.

17.* *Bulletin No. 5*. By Erasmus Haworth and G. E. Ladd, 86 pages, 5 plates and 5 figures. Jefferson City, July, 1891.

18.* *A Preliminary Report on the Coal Deposits of Missouri*, by Arthur Winslow, 226 pages, 131 illustrations and 1 map, 8vo, cloth. Jefferson City, November, 1891.

19.* *Vol. II. A Report on the Iron Ores of Missouri*, by F. L. Nason, 366 pages, 8 plates, 62 illustrations and 1 map, 8vo, cloth. Jefferson City, December, 1892.

20.* *Vol. III. A Report on the Mineral Waters of Missouri*, by Paul Schweitzer, including notes of A. E. Woodward, 256 pages, 23 plates, II figures and 1 map, 8vo, cloth Jefferson City, December, 1892.

21.* *Biennial Report of the State Geologist*, transmitted to the 37th General Assembly, Arthur Winslow, State Geologist, 37 pages, 3 diagrams. Jefferson City, January, 1893.

22.* *Vol. IV. Paleontology of Missouri (part I)*, by C. R. Keyes, 271 pages, 32 plates and 9 figures, 8vo, cloth. Jefferson City, June, 1894.

23.* *Vol. V. Paleontology of Missouri (Part II)*, by C. R. Keyes, 266 pages, 24 plates and 2 figures, 8vo, cloth. Jefferson City, June, 1894.

24.* *Vol. VI: Lead and Zinc Deposits (Part I)*, by Arthur Winslow, 287 pages, 12 plates and 71 figures, 8vo, cloth. Jefferson City, July, 1894.

25.* *Vol. VII. Lead and Zinc Deposits (Part II)*, by Arthur Winslow, 383 pages, 29 plates and 268 figures, 8vo, cloth. Jefferson City, July 1894.

26.* *Vol. VIII. Annual Report with Accompanying Papers*, by C. R. Keyes, 395 pages, 30 plates, 16 figures and 1 map, 8vo, cloth. Jefferson City, December, 1894.

27.* *Biennial Report of the State Geologist*, transmitted to the 38th General Assembly, C. R Keyes, State Geologist, 60 pages, Jefferson City, January 1895.

28.* *Vol. IX. Reports on Areal Geology (Sheets 1–4)*, by C. R. Keyes, A. Winslow, C. H. Gordon, Erasmus Haworth and F. L. Nason, 430 pages, 22 plates, 53 figures, 3 folio plates and 4 maps, 8vo, cloth. Jefferson City, April, 1896.

29.* *Vol. X. Surface Features of Missouri and Bibliography* by C. R. Keyes, C. F. Marbut and J. E. Todd, 533 pages, 22 plates and 24 figures, 8vo, cloth. Jefferson City, June, 1896.

30.* *Vol. XI. Clay Deposits*, by H. A. Wheeler, E. M. ,622 pages, 39 plates, 15 figures and 2 maps, 8vo, cloth. Jefferson City, November, 1896.

31.* *Biennial Report of the State Geologist*, transmitted to the 39th General Assembly, C. R. Keyes, State Geologist, 63 pages, 7 plates and 2 figures. Jefferson City, December, 1896.

32.* *Vol. XII. Areal Geology (Sheets 5-10)*, E. M. Shepard, C. F. Marbut and G. C. Broadhead, edited by C. F. Marbut, 656 pages, 13 plates, 39 figures and 6 maps, 8vo, cloth. Jefferson City, December, 1898.

33.* *Biennial Report of the State Geologist*, transmitted to the 40th General Assembly, by John A. Gallaher, State Geologist, 68 pages. Jefferson City, December, 1898.

34.* *New Year Announcement of the Bureau of Geology and Mines*, by J. A. Gallaher, State Geologist, 27 pages. Jefferson City, January, 1900.

35. *Vol. XIII. Preliminary Report on the Structural and Economic Geology of Missouri*, by John A. Gallaher, State Geologist, 260 pages, 65 plates, 9 sections and 6 figures, 8vo, cloth. Jefferson City, September, 1900. (Weight, 46 ounces).

36.* *Biennial Report of the State Geologist*, transmitted to the 41st General Assembly, by Leo Gallaher, Act. State Geologist, 55 pages. Jefferson City, January, 1901.

FINANCIAL STATEMENT FOR 1913 AND 1914.

SUPPORT APPROPRIATION, 1913.

H. A. Buehler	$4,093.23	
V. H. Hughes	2,007.16	
F. C. Greene	1,724.13	
M. Albertson	1,053.48	
E. E. Hirdler	810.00	
G. C. Stimson	385.00	
Wm. E. Morse	325.00	
A. X. Illinski	42.50	
J. C. Ingram	189.14	
M. E. Wilson	555.70	
H. M. Scott	369.30	
G. F. Metz	102.24	
M. G. Mehl	592.58	
Theo. Gerber	78.28	
C. L. Dake	363.05	
D. C. Wysor	472.23	
Otto von Schlichten	446.34	
Stuart Weller	95.45	
Office and miscellaneous expenses	1,709.01	
P. N. Moore	54.33	
E S. Gatch	17.89	
Clark Craycroft	39.58	
E. M. Shepard	52.57	
Mound City Engraving Company	103.19	
Keuffel and Esser Company	84.55	
Baker and Company, Inc	55.06	
Lammert Furniture Company	77.25	
Hugh Stephens Printing Company	1,110.82	
Postage	450.00	
Total		$17,459.06

1914.

H. A. Buehler	$3,613.45	
F. C. Greene	1,872.63	
Stuart St. Clair	1,841.99	
C. L. Dake	760.24	
M. E. Wilson	1,295.37	
V. H. Hughes	375.00	
A. F. Truex	1,192.71	
W. C. Hogoboom	1,166.79	
Stuart Weller	794.31	
Otto von Schlichten	1,898.54	
G. B. Corless	1,245.32	
G. C. Stimson	140.00	
Wm. E. Morse	360.00	
Wm. C. Marti	500.00	
Herbert B. Chabot	332.05	
Ray R. Robinson	187.30	
W. E. McCourt	71.44	
E. H. Greene	154.10	
Lola Mitchell	240.00	
E. B. Branson	656.62	
D. K. Greger	55.87	
M. G. Mehl	578.25	
G. H. Mullenberg	289.05	
G. F. Metz	225.00	
F. L. Johnson	507.50	
V. H. Gottschalk	300.00	

Sidney Reich	$370.32	
G. H. Cox	141.03	
Office and miscellaneous expenses	1,599.96	
E. M. Shepard	49.00	
Clark Craycroft	54.06	
Philip N. Moore	15.09	
Buxton and Skinner Printing and Stationery Company	30.75	
Henry Heil Chemical Company	45.33	
R. B. Marshall	505.00	
W. Schiller and Company	46.17	
Arnold Motor and Supply Company	857.75	
Hall Safe and Fixture Company	135.00	
W. J. Mitchell	235.00	
Schuman Brothers	167.87	
C. R. Keyes	150.00	
John Hunter	195.30	
Missouri School of Mines and Metallurgy	58.00	
Mound City Engraving Company	172.80	
A. Hoen and Company	1,803.00	
Chas. S. Jenkins	50.00	
Gast Bank Note Company	392.50	
Owens Paper Box Company	43.50	
St. Louis Paper Can and Tube Company	78.20	
Bausch and Lomb Optical Company	263.70	
A. J. Nystrom and Company	450.00	
George W. Perkins	115.00	
Postage	500.00	
Total		$29,177.86
Total for 1913 and 1914		46,636.92
Bills due: Hugh Stephens Printing Company for binding and printing. Buxton and Skinner Printing and Stationery Company for map engraving.		

TOPOGRAPHIC FUND.

1913.		
F. W. Hughes	$2,886.88	
E. L. McNair	1,949.24	
J. G. Staack	596.89	
O. H. Nelson	424.93	
J. A. Duck	550.86	
F. B. Barrett	316.76	
Kyle D. Seymour	47.67	
Miss N. Swenson	76.50	
Total		$6,849.73
1914.		
F. W. Hughes	$3,516.32	
J. G. Staack	150.00	
O. H. Nelson	87.50	
E. L. McNair	68.01	
W. L. Miller	422.95	
E. C. Bibbee	530.98	
G. W. Lucas	47.89	
G. C. Anderson	1,140.66	
R. L. Harrison	2,108.81	
J. M. Rawls	50.00	
Total		8,123.12
Total for 1913 and 1914		$14,972.85